What Remote Sensing Can Do and What Not for Habitat Mapping and Quality Assessment – Lessons from the “ChangeHabitats2” Project

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1. Introduction

The EU Habitats Directive (European Commission 1992) requests a regular monitoring of the status of habitats and species listed in its annexes. The current state of the art in EU habitat monitoring is time-consuming field work, involving many specialists working at a very detailed mapping scale, often in rather inaccessible or dangerous terrain. Based on the field mapping, conservation status is assessed and reported to the EU every six years. However, working all the Sites of Community Interests would take more than 10 years in all EU Member States. Furthermore, this traditional scheme of field mapping raises questions of repeatability (Hearn 2011), inter-observer variability (Spanhove et al. 2012) and is unfeasible over large or inaccessible areas. Thus the EU funded Marie Curie project “ChangeHabitats2 – Network for Habitat Monitoring by airborne-supported field work” aims to develop a cost- and time-efficient, airborne-supported approach using innovative image analysis and effective field work techniques for Natura 2000 assessment.

Presently, field work is supported by aerial photos (BfN 2009). Orthophotos might enable scientists to assign habitat types to photographic features; however, the procedure is still a very rough interpretation and does not replace field work at all. Satellite images are used as well, but they are usually at a lower spatial resolution; however, their high temporal resolution supports detection of various habitats based on seasonality (Förster et al. 2012).

As a more recent technique Airborne Laser Scanning (ALS aka LIDAR) is increasingly used for mapping terrain topography and vegetation cover. It relies on distance measurement based on the travel time of laser pulses, from which terrain surface and vegetation canopy elevation are derived. For many European states and regions, ALS data are already available or being routinely collected.

Thus the “ChangeHabitats2” project aims at integrating ALS-derived maps and indicators for supporting Natura 2000 habitat mapping and assessment. Since the laser pulse penetrates the vegetation canopy, vertical vegetation structure can be measured, and even features below a forest vegetation can be identified.

2. Parameters Used in Habitat Quality Assessment

When mapping habitat quality within the Natura 2000 framework a great number of parameters has to be collected, most of which can be assigned to one of the three categories: species, structure and disturbances. Among species those that are constitutive for the habitat type (dominating species, characteristic species or indicator species) and invasive species (both native and exotic) have to be mapped. The parameters which have to be recorded for habitat structure are obviously heavily dependent on vegetation formation. Specific parameters for habitat quality in forests are deadwood (both lying and standing) and trees as habitats, i.e. very old trees, trees with holes or big nests of e.g. birds of prey or black stork, or tinder fungus, bark fractures, living trees with fractured stems/crowns and upright root system of fallen trees. For grasslands the stratification, internal structure (e. g. percentage of tall and shorter growing grasses, cover of small herbs, herbs with rosettes) or the spatial vegetation structure (i.e. changes in sub-types on a fine scale, small-scale mosaic with other grassland habitats) are of relevance. The third parameter category is disturbance, both anthropogenic and by “natural” factors, like open soils, diggings of the wild boar, encroachment of species with ruderal or competitive strategies or certain life forms like tall grasses and shrubs, eutrophication, changes in water regime, roads, power lines, buildings and waste heaps.

Especially in silviculture there are a number of applications of airborne laser scanning to derive parameters for forest structure. Some studies have successfully derived structural parameters of forests relevant for habitat quality from LIDAR data, e.g. herbaceous layers (Vehmas et al. 2009) or understorey vegetation cover (Wing et al. 2012). Structural parameters have been applied as predictors for avian diversity in forests, like vertical distribution of canopy elements as an indicator for forest bird species richness (Goetz et al. 2007), indices for foliage height diversity predicting bird species diversity (Clawges et al. 2008), or statistics of canopy height distribution, vegetation layers and canopy openness for forest bird assemblages (Müller et al. 2010). Habitat suitability for individual species could be successfully predicted from LIDAR data for capercaillie (Graf et al. 2009: relative tree canopy cover, mean height of tree canopy, tree edge length) and woodpeckers (Garabedian et al. 2014: basal area, tree density). Habitat quality has been also inferred directly from LIDAR sensor data by Simonson et al. (2013).

3. Habitat Quality Assessment in the Light of LIDAR Data

As the examples from Section 2 show, previous habitat quality assessment approaches based on remote sensing are mostly founded on indirect parameters, often with a rather loose relationship to habitat suitability only. Two approaches attempting to use more direct parameters are (i) vertical heterogeneity (as derived from the absolute deviation of height LIDAR returns) as in indicator for snags (i.e. standing dead trees), which correlated well with habitat suitability indices as modelled from field investigations (Martinuzzi et al. 2009), and modelling of microtopographic features from LIDAR data as indicators of habitat factors (microclimate, soil moisture) for predicting optimum sites in the re-introduction of threatened species (Questad et al. 2014). Nevertheless, snags in the study of Martinuzzi et al. (2009)

were not identified directly, but rather derived from statistical correlations between LIDAR-derived measures of variation in canopy and snags mapped in the field.

For a more process-orientated approach which can be transferred to other sites and allows predictions of responses to changes in habitat quality, parameters which are more closely related to habitat quality and procedures to identify these parameters directly are needed. Thus, within the "ChangeHabitats2" project we attempted to identify some of the habitat features relevant for habitat quality assessment directly from LIDAR data, especially (i) lying and standing deadwood and dense shrub layers in forests; (ii) bare surfaces, field tracks and microtopography (e.g. erosion channels and erosion slopes) in (alkali) grasslands. We tried to follow the local Natura 2000 mapping scheme in this case as close as possible from the sensor data, attempting to identify every variable that the mapping scheme refers to.

An approach to derive information about the abundance of sub-dominant vegetation layers for forests was developed and tested in the Nagyerdö forest (East Hungary). The presence of shrub layers could be estimated with high accuracy. The identification of sub-dominant tree layers was also possible, but not as successful as for the shrub layers. In addition, a method to automatically detect deadwood in forests was developed. Via filtering the ALS point cloud according to surface roughness estimates we were able to remove echoes representing shrub vegetation effectively, thereby exposing objects underneath. Thus fallen trees could be identified very reliably. Also, the derived roughness parameters were found to be a useful indication on the decay level of the detected tree stems. However, no reliable estimator could be found for the identification of standing dead trees (Mücke 2014).

In the Pannonian alkali landscapes of the Hortobágy National Park (East Hungary) we tested the correlation between fine-scale differences in vertical position and vegetation pattern, using field vegetation data and Digital Terrain Model derived from ALS data. We demonstrated that main vegetation categories of alkali and loess grasslands are positioned along a vertical elevation gradient of a couple of decimeters. Microtopographic variables were more useful than even spectral variables — both derived from full-waveform ALS — for the classification of species and structures in these alkali and loess grasslands. Although comparisons with multi-spectral imagery have to be done, full-waveform ALS may have an edge over multi-spectral imagery for the mapping and habitat quality assessment of these habitats. The revealed elevation-vegetation correlations provide new perspectives in the ALS based vegetation mapping of alkali landscapes and also for other open heterogeneous habitat complexes such as large alluvial plains, sand dune vegetation or vegetation mosaics of fens and dry grasslands.

The extent to which such habitat quality parameters have been successfully identified and the potential of both successfully and not successfully identified parameters for representing ecological/habitat quality categories will be an important guideline for future research, not only for assessment of Natura 2000 conservation status to provide spatially explicit estimates of habitat quality over large areas, but also for other habitat quality assessment schemes like High Nature Value. Furthermore, parameters derived from high-resolution airborne laser scanning can be used for studying dynamics in plant communities like forest regeneration after disturbances and processes in ecosystems such as transfer of energy and dispersal of diaspores dependent on the three-dimensional spatial structure of system components.

Acknowledgements

This study was funded by the ChangeHabitats2 project (Marie Curie - FP7-PEOPLE-2009-IAPP).

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