The Potential of ALS Data for Habitat Classification in Forest Landscapes – First Results

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1. Introduction

The preservation and protection as well as the improvement of the environment are stated as essential objectives of general interest. This includes the conservation of natural habitats of wild fauna and flora (European Commission 1992). The European Union's Habitats Directive (HD) and the Natura 2000 network provide a framework for classification and monitoring of different habitat types (Requena-Mullor et al. 2018). By date, these HD classifications are mainly expert-based investigations in the field. Within the presented study, a data-driven approach based on airborne laser scanning (ALS) data for HD classification in forest landscapes is tested. The aim is to reproduce the latest available HD classification for two study sites in the municipality of Vienna using supervised classification. Habitat types are basically defined by the occurring vegetation, terrain and soil characteristics. Previous studies show the potential of airborne ALS data for deriving forest structure (Hollaus et al. 2006, Lindberg et al. 2012) and species classification (Hollaus et al. 2009, Koenig and Höfle 2016). Furthermore, the suitability of ALS data for detailed terrain modelling, in particular in forested areas, is shown by Kraus and Pfeifer (1998). ALS data for different approaches of habitat classification or biodiversity monitoring are used e.g. in Räsänen et al. (2014), Coops et al. (2016) and Guo et al. (2017). For the HD classification, different features describing terrain, location and vegetation structure are derived from ALS point cloud data and rasterized to a 1 m grid. The features are examined with regard to their discriminant power for different HD classes and usability for random forest classification on 1 m pixel scale.

2. Data and Methods

2.1 Habitats Directive Classification

The HD classification scheme differentiates nine major habitat groups with a total of 229 habitat types (European Commission 2006). Within the two study sites, 22 different habitat out of five major habitat groups occur. The mapping of the HD classification of the green areas within the municipality of Vienna is provided as open data (Stadt Wien – https://data.wien.gv.at, 2020). After excluding ten habitat types due to low incidence, twelve habitat types out of three major habitat groups (freshwater habitats, natural and semi-natural grassland formations and forests) are considered. For this study, the habitat types were further limited to forests. Table 1 shows a summary and description of the considered habitat types.

2.2 Study Sites

Two different areas representing the two main green landscapes in Vienna are chosen for investigation: (A) hilly, primary forested areas in the west of Vienna and (B) river meadows and riparian forests along the Danube River. Study site A, located in the Vienna Woods and part of the Wienerwald Biosphere Reserve, covers 21.8 km². The altitude of study site A varies between 214 m and 515 m a.s.l., is hilly and cut by three major valleys. Study site B is located in the southeast of Vienna, along the riparian forests of the Danube River. The 10.3 km² of study site B cover the Viennese part of the Donau-Auen National Park. The mainly flat area stretches from 147 m to 163 m a.s.l. and shows incidences of a former dominant and now partly regulated braided river system and a floodplain landscape. The detailed distribution of the habitat types within the two study sites is shown in Table 1.

Published in: Markus Hollaus, Norbert Pfeifer (Eds.): Proceedings of the SilviLaser Conference 2021, Vienna, Austria, 28–30 September 2021.
Technische Universität Wien, 2021. DOI: 10.34726/wim.1861
This paper was peer-reviewed. DOI of this paper: 10.34726/wim.1940

Table 1. HD types occurring in the study sites within the municipality of Vienna, according to European Commission (2006). The sign * prior to the name indicates priority habitat types.

Habitat group	NATURA 2000 Code	Covering study site	Description
Forests	9110	A (1%)	Luzulo-Fagetum beech forests
	9130	A (31.3%)	Asperulo-Fagetum beech forests
	9170	A (62.7%)	Galio-Carpinetum oak-hornbeam forests
	9180	A (0.8%)	* Tilio-Acerion forests of slopes, screes and ravines
	91E0	A (2.4%) B (10%)	* Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)
	91F0	B (90%)	Riparian mixed forests of Quercus robur, Ulmus laevis and Ulmus minor, Fraxinus excelsior or Fraxinus angustifolia, along the great rivers (Ulmenion minoris)
	91G0	A (1.8%)	*Pannonic woods with Quercus petraea and Carpinus betulus

2.3 ALS data and feature extraction

The ALS data for the whole municipality of Vienna was acquired between November 9th and November 24th 2015 under leaf-off conditions. Two different sensors providing full waveform analysis were used: a Riegl LMS-Q680i and a Riegl LMS-Q560 (RIEGL Laser Measurement Systems, Horn, Austria). The acquisition resulted in a point density of > 16 echoes/m² for 97% of the whole city area.

The ALS features derived from the point cloud are grouped in terrain features, structure features, insolation features and full waveform features. In total, 22 features were derived on a 1 m grid.

2.4 Exploratory statistics and classification

Primarily, the distributions of the feature values grouped by the different habitat types were analysed for each study site. For the assessment of the feature performance for classification, a random forest model with recursive feature elimination was trained and a 10 fold spatial cross validation (CV) was performed to classify the whole study areas.

3. Results and Discussion

Chosen distributions of the feature values amongst the different habitat types are shown in Figure 1. Exemplarily, the horizontal distance to the closest water surface shows clear differences between some forest groups. The median TWI shows varies between the classes 9170 and 9180, which show similar distributions most other features. The first visual interpretation indicates potential of the derived features for classification of the different forest habitat types. The leave-off condition of the data acquisition limits the direct species determination of the trees to examination of the branch structures. Leave-on data could add valuable information about crown and canopy. Random forest classification with a mapping unit of 1 m² using samples of max. 2500 pixels per HD type and recursive feature selection results in OOB errors of 19.5% (study site A) and 16.7% (study site B). The overall accuracies determined by the predictions of the 10 fold spatial CV are 66% (study site A) and 80% (study site B).

4. Conclusion and Outlook

The current study shows that features derived from ALS point cloud data have high potential for classification of different habitat types of the European Union's Habitats Directive in forest landscapes. Chosen features, like horizontal distance to closest water surface, are useful for classification of different forest habitat types. Integration of further data sets with high temporal resolution for identification of phenological characteristics as well as sprectral information (Sentinel-1 and Sentinel-2) and point clouds from image matching are subject of ongoing investigations.

Acknowledgements

The ALS data are provided by the municipality of Vienna. The ALS processing and classification work is founded by the FFG Austrian Space Applications Programme ASAP 15, grant agreement number 881400, Anwendungsmöglichkeiten von Sentinel-Daten für ein Monitoring im Umwelt- und Naturschutz in Städten am Beispiel Wien, SeMoNa22.

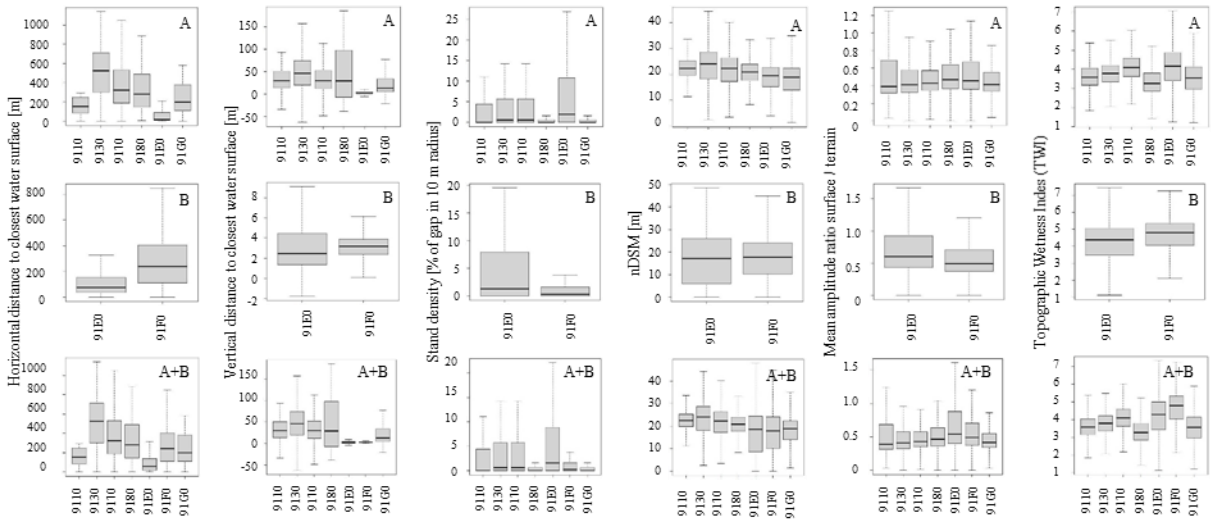

Figure 1: Boxplots of the distribution of chosen features of different HD types (Natura 2000 Code, see Table 1) for both study sites A and B and in combination.

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