Modelling Biodiversity and Forest Structure Using Hyperspectral and LIDAR Remote Sensing

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Background

Understanding patterns of biodiversity and forest structure is an important issue in ecological research and conservation in complex forest ecosystems. Spatially comprehensive assessments require the use of novel remote sensing techniques. We investigate biodiversity and forest structure of a mixed temperate forest in the Bavarian Forest National Park, Germany, using airborne hyperspectral (HyMap) and LIDAR data, which promise to provide the necessary resolution and accuracy.

Research Question

Which information on forest structure and biodiversity can be derived from hyperspectral & LIDAR sensors?

Methods

Study Area

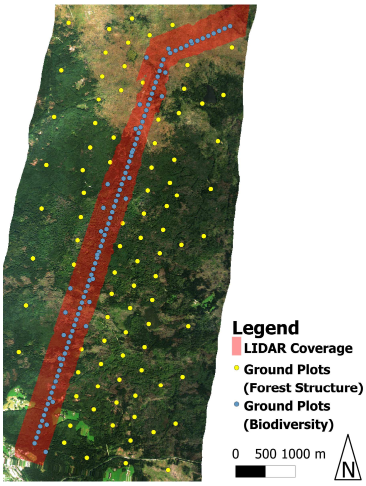

Fig. 1: HyMap true color image of study area in the Bavarian Forest national park, Germany.

Ground Data

Forest Structure
102 ground plots
- basal area
- fraction of basal area
- mean DBH

Biodiversity:
106 ground plots (P/A for grasses, herbs, ferns, trees)
- α-diversity: Species number
- β-diversity: Sørensen multiple plot similarity

Remote Sensing Data

HyMap
- 7m²
- 125 bands

LIDAR:
- 25 points/m²
- full waveform

Preprocessing

HyMap
- MNF transformation
- pixel aggregation

LIDAR
- penetration ratios
- canopy structure
- pixel aggregation

Data Analysis

Random forest decision trees using HyMap and LIDAR derived variables as predictors and all plots as training samples.

Model quality assessment: R^2 based on "out of bag" samples.

Results

1. Forest Structure - HyMap

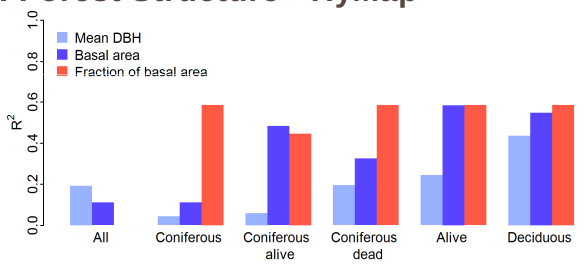

Fig. 2: Model performance on forest structure measures, modified by state and kind of vegetation.

2. Biodiversity – HyMap & LIDAR

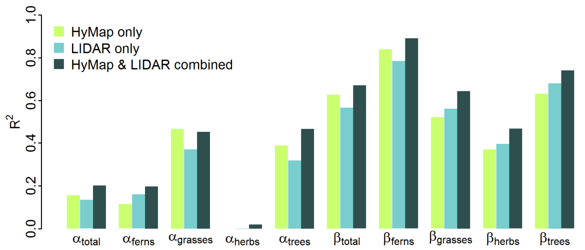

Fig. 3: Model performance on α and β-diversitiy, modified by functional groups.

Conclusions

1. **Forest β-diverstiy can be derived both from hyperspectral and LIDAR sensors. Optimal results were obtained combining both.**
2. **HyMap provides reliable information on the fractional basal area split into living, dead, deciduous and coniferous trees.**
3. **Forest α-diversity of most functional groups as well as mean DBH could not be derived successfully.**

Next steps

1. Using hyperspectral indices as predictors (e.g. PRI).
2. Modelling communities instead of indices.
3. Modelling bird, beetle and spider assemblages combining LIDAR & HyMap in comparison to previous studies using LIDAR only [1,2,3].
4. Determining spectral & spatial resolution requirements of remote sensing data for biodiversity modelling.

References:
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[2] Müller, J.; Moning, C.; Bässler, C.; Heurich, M. & Brandl, R. (2009) Using airborne laser scanning to model potential abundance and assemblages of forest passerines. *Basic and Applied Ecology,, 10*, 671-681
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