MADALGO
CENTER FOR MASSIVE DATA ALGORITHMICS

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Estimation of Ecologically Relevant Understory Light Conditions using LiDAR Data

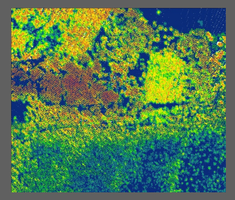
Introduction

OBJECTIVES

- To develop proxies for canopy cover and canopy closure based on discrete-return LiDAR data.
- To determine whether there is a relationship between the canopy structure variables and the understory light conditions in vegetation plots, predicting a stronger relationship for angular canopy closure than vertical canopy cover.

BACKGROUND

- Canopy cover and canopy closure are two closely related measures which are useful for estimating the microclimate and light conditions at the forest floor, for assessing habitat suitability for different plants and animals, and for estimating functional variables such as Leaf Area Index.
- Canopy cover is the proportion of the forest floor covered by the vertical projection of tree crowns.
- Canopy closure is the proportion of the sky obscured by vegetation when viewed from a single point.
- Canopy closure provides a better description of the light conditions under a canopy than canopy cover as all the directions in which light reaches a point below the canopy are taken into consideration (Jennings *et al.*, 1999).



- Airborne laser scanners (ALS) use light detection and ranging (LiDAR) to obtain geo-referenced points on and above the terrain.
- Ellenberg indicator values for light (EIV_{light}) for plant species have been developed as estimates of the preferred light conditions for plants in Central Europe. EIV_{light} range from 1 to 9, with a value of 1 denoting plants which grow in deep shade, and 9 denoting those that grow in full sunlight (Ellenberg, 1988).

DATASETS

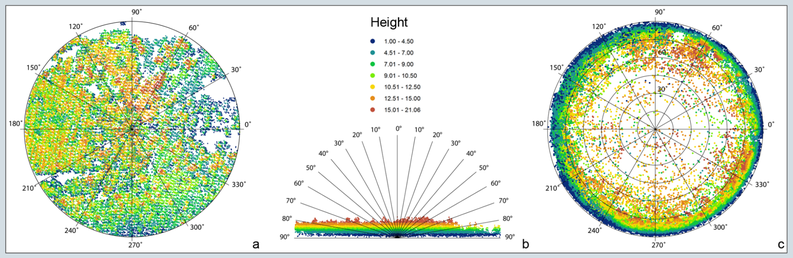
- ALS data were collected in April and May 2006 by COWI, an international engineering and planning company, using an Optech ALTM 3100 airborne laser scanner.
- Species occurrence data in the study area were collected under the National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environment (NOVANA) within 5-m radius plots in the open sites, and in 5- and 15-m radius plots in the forest sites.

Study Area

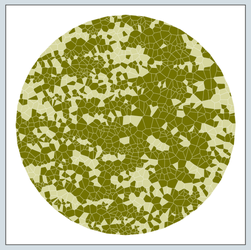
The **study area** includes seven NOVANA sites, which constitute three groups of sites, each having both a semi-open habitat and an adjacent forest. The 150 plots in open sites, and 60 plots in forest sites cover an area of 177 ha.

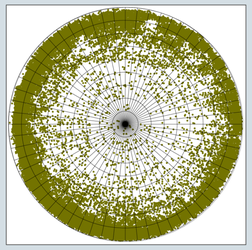
Methodology

- Canopy cover was estimated as the percentage of each plot covered by Thiessen polygons containing points 1 m or above from the ground.
- Canopy closure was estimated for plots in the forest sites. Cartesian coordinates of the ALS points within a specified distance from the plot centres were converted to their spherical coordinates. The x, y and z coordinates of the points were thus converted to θ (theta), φ (phi) and R.



ALS points within 100 m of the centre, and at heights of 1 m or above from the ground in a sample plot, displayed by elevation (a); Points are displayed by their azimuth angle (θ) from the positive x-axis (a) and zenith angle (φ) from the positive z-axis (b) with the centre of the plot as the origin. Points displayed in the polar coordinate system with the azimuth angle as the angular coordinate and the zenith angle as the radial coordinate (c).



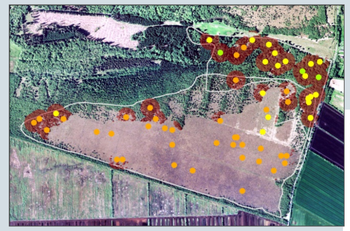


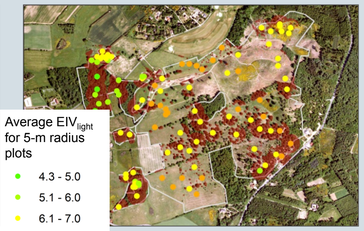
Proxy for canopy cover (left): Thiessen polygons generated from the ALS points within 15 m from the plot centres. The polygons in dark green are at or above 1 m from the ground.

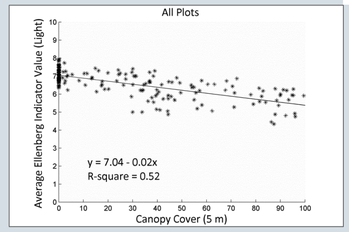
Proxy for canopy closure (right): The resolution of the pyramidal elements - azimuth and zenith angle intervals - had a large influence on the estimated canopy closure.

- The average EIV_{light} were calculated within 5-m radius of the open and forest plots, and also within 15-m radius for the forest plots.
- The estimates of canopy cover and closure from ALS data were compared with the average EIV_{light} for all the plots.

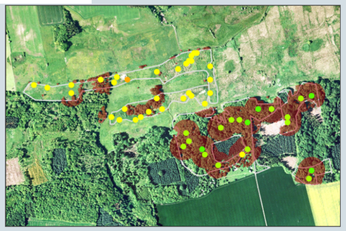
Results





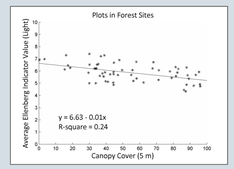


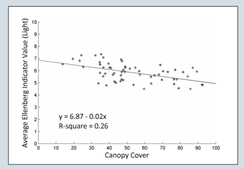
Correlations between the ALS-based estimates of canopy cover for all plots and average EIV_{light}.

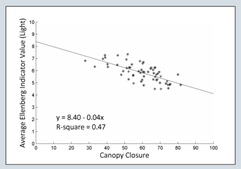


ALS points within 50-m radius of the plot centres, and above 1 m from the ground, are displayed as red dots. Average EIV_{light} are also shown.

- The plant-based EIV_{light} generally was higher for the open sites than for the forest sites, and also in most cases corresponded with ALS-based canopy cover, with higher EIV_{light} being associated with lower canopy cover.
- Overall, the correlation between LiDAR-based canopy closure and EIV_{light} for the forest plots was higher (r = -0.69) than the correlations between ALS-based canopy cover and EIV_{light}.







Correlations between the ALS-based estimates of canopy cover for the forest plots and average EIV_{light} for the 5-m plots (left), and between the ALS-based estimates of canopy cover (centre) and canopy closure (right) and average EIV_{light} for the 15-m plots.

References

[1] Alexander, C., Moeslund, J. E., Bøcher, P. K., Arge, L. & Svenning, J-C. *Estimation of ecologically relevant understory light conditions using airborne laser scanner (LiDAR) data*. Submitted to Remote Sensing of Environment.

[2] Ellenberg, H. *Vegetation ecology of Central Europe (4 edition ed.).* Cambridge: Cambridge University Press. 1988.

[3] Jennings, S.B., Brown, N.D. & Sheil, D. *Assessing forest canopies and understorey illumination: Canopy closure, canopy cover and other measures*. Forestry, 72, 59-73, 1999.