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Detecting a keystone species European aspen in boreal forests with airborne hyperspectral, LiDAR and UAV data with machine learning methods

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Sustainable forest management increasingly highlights the maintenance of biological diversity and requires up-to-date information on the occurrence and distribution of key ecological features in forest environments. Different proxy variables indicating species richness and quality of the sites are essential for efficient detecting and monitoring forest biodiversity. European aspen (Populus tremula L.) is a minor deciduous tree species with a high importance in maintaining biodiversity in boreal forests. Large aspen trees host hundreds of species, many of them classified as threatened. However, accurate fine-scale spatial data on aspen occurrence remains scarce and incomprehensive.

We studied detection of aspen using different remote sensing techniques in Evo, southern Finland. Our study area of 83 km^2 contains both managed and protected southern boreal forests characterized by Scots pine (Pinus sylvestris L.), Norway spruce (Picea abies (L.) Karst), and birch (Betula pendula and pubescens L.), whereas European aspen has a relatively sparse and scattered occurrence in the area. We collected high-resolution airborne hyperspectral and airborne laser scanning data covering the whole study area and ultra-high resolution unmanned aerial vehicle (UAV) data with RGB and multispectral sensors from selected parts of the area. We tested the discrimination of aspen from other species at tree level using different machine learning methods (Support Vector Machines, Random Forest, Gradient Boosting Machine) and deep learning methods (3D convolutional neural networks).

Airborne hyperspectral and lidar data gave excellent results with machine learning and deep learning classification methods The highest classification accuracies for aspen varied between 91-92% (F1-score). The most important wavelengths for discriminating aspen from other species included reflectance bands of red edge range (724–727 nm) and shortwave infrared (1520–1564

nm and 1684–1706 nm) (Viinikka et al. 2020; Mäyrä et al 2021). Aspen detection using RGB and multispectral data also gave good results (highest F1-score of aspen = 87%) (Kuzmin et al 2021). Different remote sensing data enabled production of a spatially explicit map of aspen occurrence in the study area. Information on aspen occurrence and abundance can significantly contribute to biodiversity management and conservation efforts in boreal forests. Our results can be further utilized in upscaling efforts aiming at aspen detection over larger geographical areas using satellite images.