Detection of wood decay in Norway spruce trees using airborne hyperspectral data

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Pathogenic fungi causes wood decay in Norway spruce trees producing severe economic losses in the forestry sector. Currently no efficient methods exist to detect infected trees; its detection could potentially lead to improvements in forest management and could help in reducing economic losses. In this study, airborne hyperspectral data were used to detect the presence of wood decay in Norway spruce trees.

Two forest areas located in Etnedal (dataset I) and Gran (dataset II) municipalities, in southern Norway, were analysed. For dataset I, the field data (13,488 trees) were collected using a cut-to-length harvester: each harvested tree was geolocated by the machine and the wood decay presence was recorded by the harvester operator. In dataset II, field data (1297 stumps) were collected manually: after harvesting the positions of the stumps were located using a GPS and the presence of wood decay at the stump was recorded. For both datasets hyperspectral images were acquired by two sensors operating in the VNIR and SWIR parts of the spectrum.

Individual tree crowns (ITCs) were delineated using airborne laser scanning (ALS) data adopting the algorithm implemented in the function *itcLiDAR* of the R package *itcSegment*. The delineated ITCs were matched with the field data and the pixels of the hyperspectral images overlapping each ITC were extracted. Different approaches to deal with pixels inside each ITC were considered: in particular, pixels were either aggregated to a unique value per ITC (i.e., mean, weighted mean, median, centermost pixel) or analysed in an unaggregated way. Wood decay presence for each ITC was predicted using multiple methods: concerning the aggregate pixels we used logistic regression with LASSO, and feed forward neural networks, while for the unaggregated data convolutional neural networks combined was

used. In this latter case, both the original bands and the first five principal components were considered as input features.

The results showed that wood decay could be detected, although the accuracy varied between the two datasets. For Dataset I using the aggregated data we obtained the best result with a logistic regression with LASSO and the aggregation based on the weighted mean (OA = 63.7%), while with the un-aggregated data the best result was obtained using a convolution neural network with the first five components of a principal component analysis as input (OA = 65.5%). For dataset II, using the aggregated data, the best result was obtained with the logistic regression with LASSO and data aggregated using the weighted mean (OA = 61.4%), while for the un-aggregated data the best result was obtained using a convolution neural network with all the bands as input (OA = 57.7%). In general, the differences among aggregated and unaggregated data were small.