Comparison of Forest Variable Inventory Methods Using VHR Optical Satellite Imagery and Airborne Laser Scan data – Results of NewForest study

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Traditionally the forest inventory has been made visually from aerial images and by field visits which is costly and slow. New methods based on airborne laser scanner (ALS) and aerial images, and on satellite images have emerged in last two decades, and are increasingly being utilized for diverse purposes. However, a breakthrough in operational usage has not yet been achieved due to the high price of the remote sensing material or due to the inadequate accuracy for operative species-wise inventory.

The objective of NewForest (2009 – 20010) project was to develop remote sensing data analysis chains that increase the accuracy of remote sensing forest inventory methods. The accuracy increase was foreseen to be achieved through applying the latest developments in the very high resolution (VHR) satellite data analysis and in the airborne laser scanner/aerial image data interpretation. One major target of this study was to produce accuracy/cost assessment between estimates based on data from VHR satellites and from ALS/aerial images using common target area, common ground reference data and common performance criteria.

The part of the study that exploited VHR satellite data focused on the combination of individual tree crown (ITC) information (location, tree species, tree crown width) with an existing forest variable estimation method. The combination was foreseen to improve the present species-wise forest variable estimates.

A new software module (called StemMixer) and neural network models were developed for this task. The results were compared with average forest variable estimates that were produced with VTT in-house software (called Probability method). The best results were achieved with the neural network models, which improved the accuracy with most of the estimated variables: the relative stand level RMS errors for total stem volume estimates was 37%. Species specific results were 63%, 52% 57%, and for pine, spruce, deciduous trees. Inclusion of the ITC data did not improve the results significantly.

Results of ALS study demonstrate that alpha shape metrics can be used in area-based inventories combined with other ALS and aerial image based variables to improve the accuracies of species specific stand attribute estimates with low pulse density data. Using alpha shape metrics as explanatory variables in addition to other metrics improved most of the species-specific stand attribute estimates obviously because they increased the information on the geometry of the tree crowns which in turn is a discriminating factor between tree species. Using ALS and aerial image data the stand level total volume estimates were predicted with 18% RMSE. Species specific results were 60%, 40% and 65% for pine, spruce and deciduous trees.

At the stand level, the performance of the satellite image estimation was similar to the airborne data method in species specific estimation for stem volume, stem number and basal area. With tree stem diameter, height, and the species-wise variables summed for total figures the

ALS/aerial image estimates performed better. The systematic errors were small, and slightly better using the VHR satellite data (typically < 10%).

The costs of the satellite based estimation varied between 60% and 85% of the costs of the airborne estimation in the estimation of the growing stock volume for a forest area of 500 km2. The variation in the costs came from the different amount of required field work, when equal accuracies with satellite and airborne methods were attempted (= relative standard error of growing stock volume). The cost depended on the required accuracy level and forest heterogeneity. The cost of the satellite based estimation was 68% of the costs of the airborne estimation if the amount of amount of ground work was fixed. The estimation was based on the announced prices of remote sensing data.

The NewForest project was conducted in co-operation of VTT Technical Research Centre of Finland and the University of Eastern Finland (UEF) in Tekes' research project category 'Public research related to innovation'. The total project budget was 460 000 €. The funding shares were: Tekes 70%, company partners 25%, research organizations 5%. The company partners were Oy Arbonaut Ltd., and FM-International Oy FINNMAP, Metsähallitus, Stora Enso Oyj, Tornator Oy. Tapio and Pohjois-Savon Metsäkeskus provided ground reference data for the study. Simosol Oy was a subcontractor of VTT providing the software module StemMixer..