

## Biomass mapping for Central Finland with Landsat images

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### Introduction

There is an increasing need for accurate biomass estimates and, therefore, methods for estimating biomass have been under constant development recently. Countries report changes in their biomass stocks and land uses for the United Nations Framework Convention on Climate Change (UNFCCC). The biomass estimates are also utilised in bioenergy research and greenhouse gas inventories. In addition to the need of greenhouse gas inventories the bioenergy use of forests is expanding rapidly due to climate policy. The feasibility

studies of bioenergy resources require accurate regional estimates for quantifying the biomass and its future supply.

Previously biomass maps have been based on ground reference that has been estimated with biomass expansion factors. Our objective here was to demonstrate a method that provides more exact biomass estimates for ground reference and thereafter improves biomass map accuracy and precision.

### Material and Methods

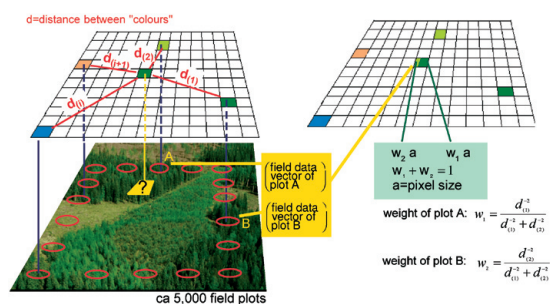
We based our analysis on the tree-level field data from the 10<sup>th</sup> National Forest Inventory (NFI) for Central Finland. The data comprised altogether 1645 NFI plots. In the collection of the NFI data every seventh tree is measured as a sample tree. In order to calculate stemwise biomasses, the tree heights and crown base heights of sample trees were generalised to tally trees. In this study, the generalisation was implemented by applying a multivariate mixed model for the given tree characteristics<sup>1</sup>. The fixed parts of the two linear models of the simultaneous system comprise tree and plot level independent variables such as the diameter at breast height, measurable stand characteristics, site quality indicators and geographical coordinates. The random model parts consist of parameters for the random cluster, plot and species effects. In the calibration of the linear mixed models the parameters for random effects were predicted by applying the standard linear prediction<sup>2,3,5</sup>. Finally, the random parameters obtained with the Best Linear Unbiased Predictor (BLUP) were used to predict heights and crown base heights for each tally tree on the sample plots within the given clusters.

Tree diameters, heights, crown base heights, temperature sums and stand ages were

thereafter used as inputs to biomass models to estimate tree biomass for the NFI plots. Fixed parts of the biomass models<sup>4</sup> were used (sample size for Scots pine 908, Norway spruce 613 and Birch 127). We estimated aboveground biomass components by adding foliage, branches and stem together, while belowground biomass constituted stump and roots. After that biomass estimates of each plot were used as a ground reference for Landsat images

The estimation of forest biomass attributes was carried out applying the *k* nearest neighbour (*k*-nn) method. The method is based on the assumption that sample plots having similar forest characteristics also have similar satellite image features, i.e. are located near each other in the *n*-dimensional satellite image feature space, where *n* represents the number of image data variables. The *k*=5 nearest neighbours were determined by the Euclidean distances between the observations in the feature space. Weighting by inverse squared Euclidean distance in the feature space was applied in the *k*-nn estimation. This method reduces the bias of the estimates.

#### K-nn method with k=2



An illustration of the *k*-nn estimation method applied in this study

$$\hat{y} = \left( \sum_{i=1}^k w_i y_i \right) / k$$

where

$$w_i = \frac{1}{d_i^2} / \sum_{i=1}^k \frac{1}{d_i^2} = \text{weight for plot } i$$

$\hat{y}$  = estimate for variable *y*

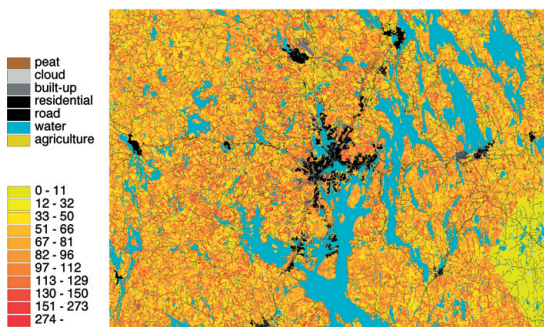
$y_i$  = measured value of variable *y* in nearest field plot *i*

*d* = Euclidean distance to the *i*th nearest neighbour plot

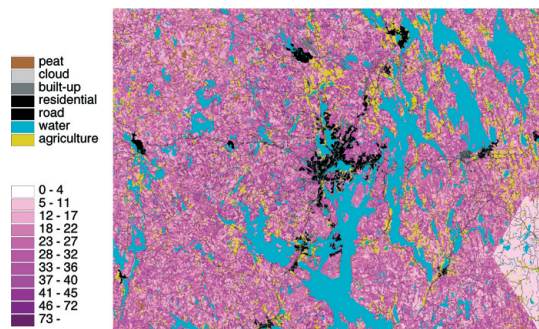
*k* = number of nearest neighbours

### Results

Preliminary results show that the combination of parametric prediction models and the *k*-nn estimation provides rational and unbiased estimates of biomass for the region of Central Finland. The study also demonstrates an approach to combine advanced modelling with NFI measurements in order to obtain state-of-art biomass estimates as a ground reference for satellite images.



Thematic map for aboveground biomass for region of Jyväskylä (tonnes of dry matter per hectare)



Thematic map for belowground biomass for region of Jyväskylä (tonnes of dry matter per hectare)

### References

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