Canopy cover estimation techniques in national forest inventories

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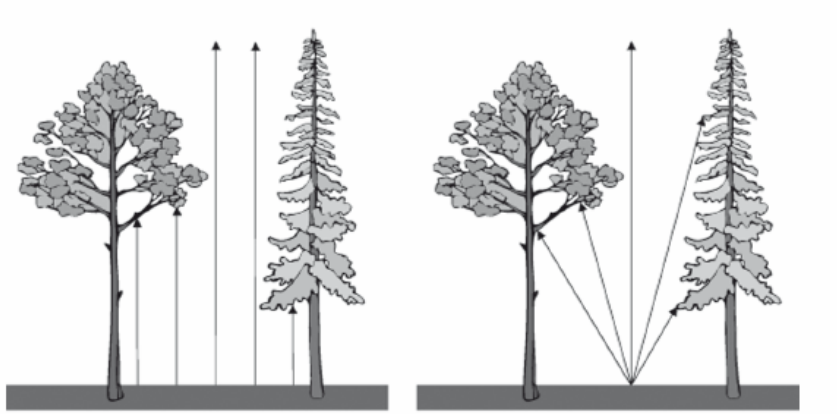
International definition of forest

- “Forest is land spanning more than 0.5 ha with trees higher than 5 metres and a canopy cover of more than 10%, or trees able to reach these thresholds in situ” (FAO 2000)
- Most forests reach this threshold easily, but e.g. natural, sparsely wooded mires can be difficult to assess
  - » If these sites are considered to be in their climax state, current cover percent can be used

Canopy cover



- Canopy cover:
  - » Proportion of the forest floor covered by the vertical projection of the tree crowns*
  - » Gaps inside ’crown envelopes’ are usually ignored
- Canopy closure:
  - » Proportion of sky hemisphere obscured by vegetation when viewed from a single point*
- Useful variables in ecological and remote sensing studies

*Jennings et al. 1999. Assessing forest canopies and under-storey illumination: canopy closure, canopy cover and other measures. Forestry 72(1): 59–74.

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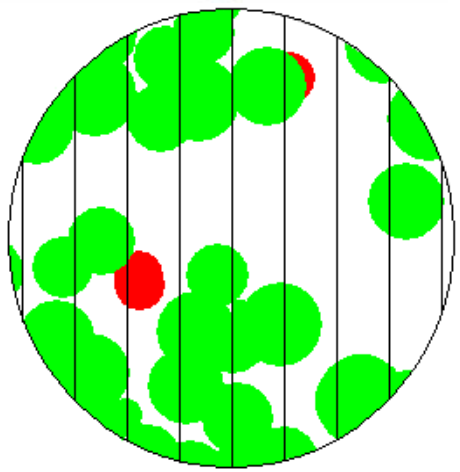
Measuring canopy cover

- Should be estimated with time-consuming transect-based sampling by using vertical (or Cajanus') tube
  - » Dot count or line intersect sampling (LIS) technique
  - » Tree mapping and crown diameter measurement
- Too laborious for large-scale inventories
  - » Available time just a few minutes, but errors larger than 10% should be avoided



Ocular estimation

- ”Walk around, look around, and make a guess”
- Problematic:
  - » Subjective
  - » Usually people tend to underestimate cover, but there are exceptions…
  - » Difficult to perceive the true size of the plot
  - » Some observers may obtain very good results, but careful training is needed

Modelling

- Canopy cover models based on standard forest inventory parameters
  - » Basal area, mean tree height, site fertility, percentage of deciduous trees etc.
  - » No field time needed, if the usual stand parameters are estimated anyway
- Beta regression technique – extension to generalized linear models
  - » Logistic link function to restrict the predictions to the standard unit interval
  - » Residuals assumed to be beta distributed (instead of usual normality assumption)

Modelling

- Local canopy cover models:
  - » Pine stands:

$$\log\left(\frac{\mu}{1-\mu}\right) = -1.119 + 0.2366G - 0.003817G^2 + 9.248\times10^{-6}G^3 - 0.09556H + 0.1606F - 0.3064P$$

  - » Spruce and deciduous stands:

$$\log\left(\frac{\mu}{1-\mu}\right) = -0.480 + 0.3249G - 0.00931G^2 + 0.000112G^3 - 0.158H - 0.00246H^2 + 0.000153H^3 + 1.52HW$$

G = basal area

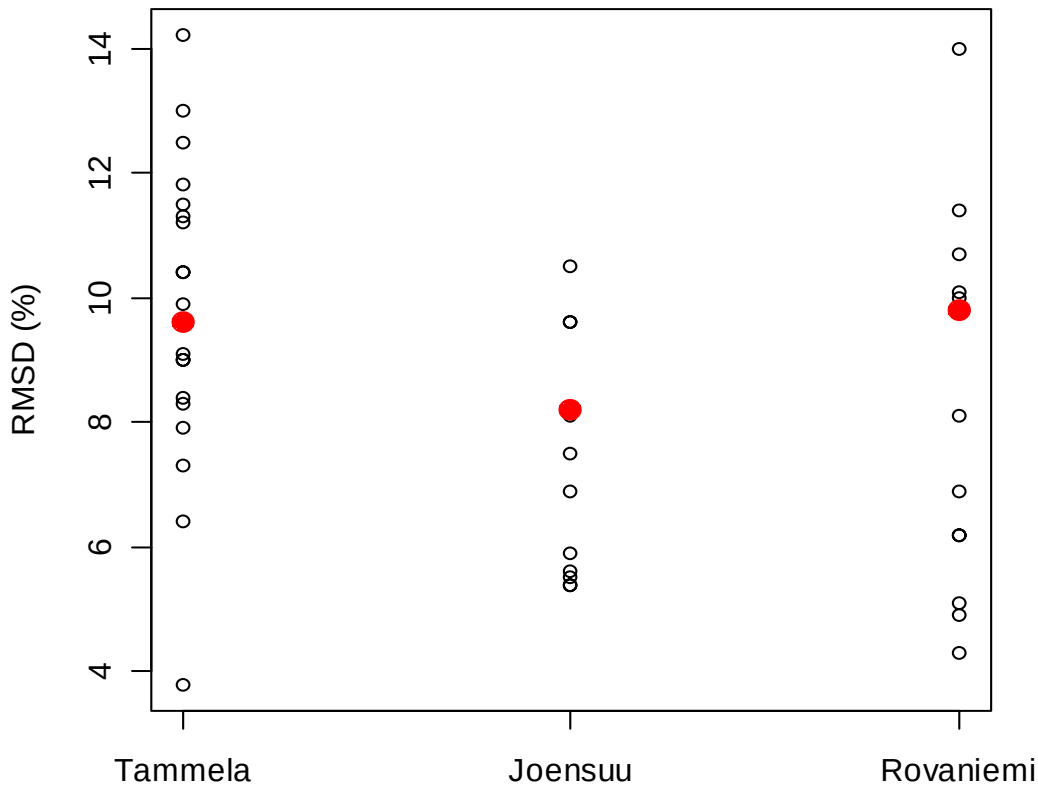
H = mean height

HW = percentage of hardwoods

F = fertile site –dummy

P = poor site –dummy

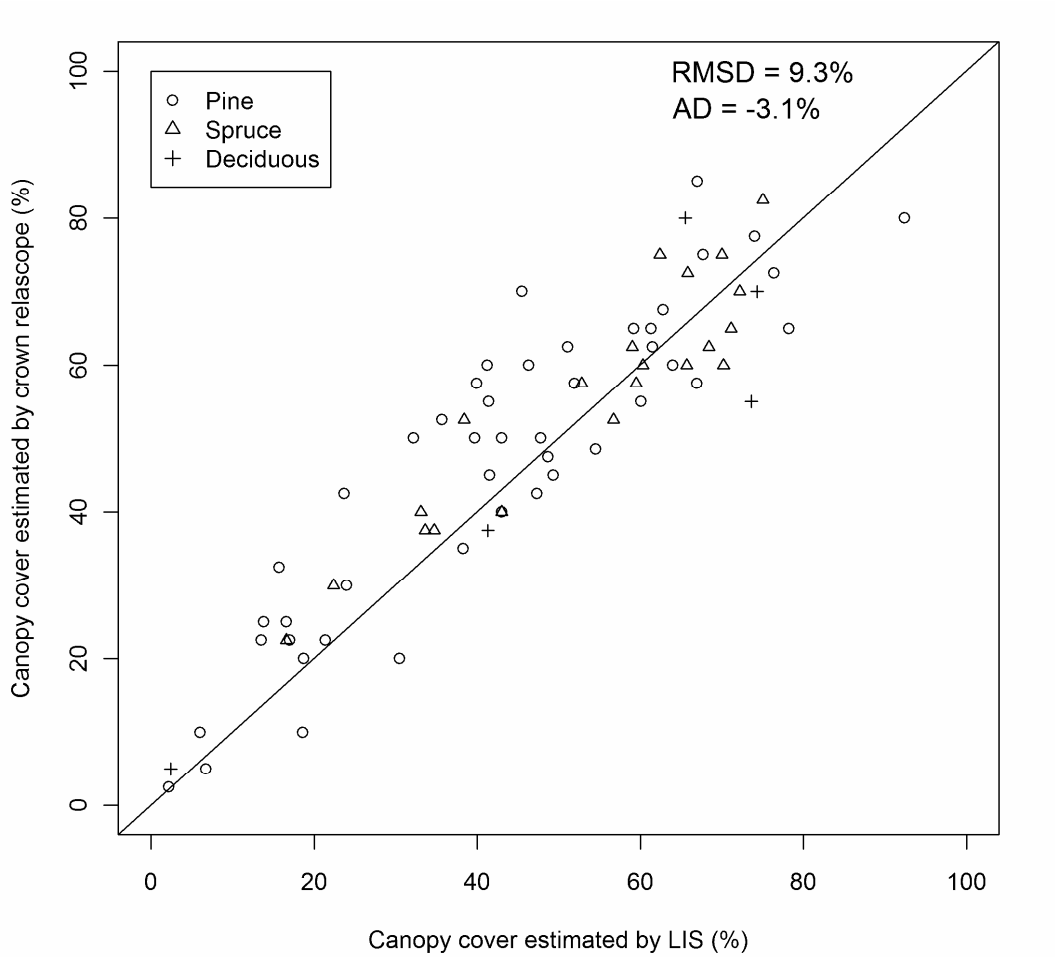
Comparison of modelled and ocular canopy cover estimates



Crown relascope

- A relascope with very large basal area factor and a very high slot
  - » Tally crowns that appear wider than the slot
  - » If BAF = 100, each included crown adds 1% to total cover percent’
- Quick, portable, cheap, quite objective
- Usually overestimates cover
  - » Effects of overlapping crowns and noncircularity
  - » Plot placement and basal area factor have a large effect on results
- Inaccurate in high cover forests, but may be useful in sites close to 10% threshold

Crown relascope with BAF = 250 vs LIS in 73 FNFI-sized plots



Stenberg et al. 2008. Can. J. For. Res., accepted.

Small test with crown relascope

- Six plots where tree locations and crown diameters perpendicular to the plot center were measured.
- The trees that were included to relascope sample were compared to those that should have been included based on their crown width and distance to plot center
- On an average 86% of the trees were classified correctly, 4% were erroneously included, and 10% were not observed even though they were actually in.
  - » Of the erroneously included trees, 80% were included because of crown asymmetry
  - » Of the unobserved trees, 53% were left out because of mensuration errors, and 28% were hidden behind other crowns
  - » Because of the unobserved trees, the ”correct” relascope cover was on an average 6.7% larger than the estimated cover

Digital photographs

- Vertical canopy images obtained with ordinary digital cameras can be used in canopy cover estimation, if angle of view is kept smaller than 50°
- Automated image analysis techniques available
- In a recent study (Korhonen & Heikkinen 2008, submitted manuscript), nine images per plot with 40°'s angle of view yielded RMSDs of 4.8% and 8.7% in two different study areas
  - » More images per plot are needed, but needed time increases
  - » Results better in high cover plots
  - » Not good for seedling or sapling stands

Remote sensing

- High resolution remote sensing should provide accurate estimates of canopy cover
  - » Airborne photography or laser scanning
  - » Effect of viewing/scanning angle?

Conclusion?

- There is no superior method for obtaining canopy cover information quickly in the field. Still, selecting a standard estimation technique (other than ocular) would improve the comparability of forestry statistics.
- Finnish NFI 2008: crown relascope is used in plots close to 10%. Elsewhere regression model estimates are checked with ocular estimation (and corrected if necessary).