Canopy cover prediction from stand density attributes: stocking, crown width, and overlap functions

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What’s a forest?
Objectives

• Estimate stand-level canopy cover from standard tree measurements
• Compare different methods of estimating density and canopy overlap adjustments
• Get your ideas on the best modeling approaches
Oregon 95-98 inventory of non-federal lands (1,424 plots)
Periodic inventory plot design

60 m between points over ~1.8 ha area

2.35 m R: seedling counts + sapling (<12.7 cm DBH) measurements

17 m R: limit of variable radius

BAF = 7 m²/ha (~30 ft²/ac)

Canopy cover transects

10 m

N
The Line Intercept Method

Cover = \dfrac{(\text{Crown Distance}) \times 100}{(\text{Transect Length})}

Upper Layer
Middle Layer
Lower Layer
Upper
Middle
Lower
Total/Combined

> 5 m
Primary measures of tree density

- **Stocking**: tree contribution to a fully-stocked stand, from growth+yield studies, based on DBH.
- **Crown width**: equations based primarily or solely on DBH
- **Stand Density Index (SDI)**: index based on DBH
Raw density equations
Different measures of crown width

R5
- maximum radius
- CW=$B_0*DBH^{B_1}$

FHM
- widest and perpendicular
- CW=$B_0+B_1*DBH + B_2*DBH^2$

R6
- widest on random azimuth
- CW=$B_0*DBH^{B_1}$
Accounting for crown overlap

- Social position adjustment:
  - Dominants + Codominants: 1.1 (0.7 if crown ratio<30%)
  - Intermediates: 0.7
  - Suppressed: 0.4

- Maximum limit (cap at 100% cover on each subplot by height strata)

- Random overlap function
Modeling approach

• Logit-transformed cover, X transformations and quadratic terms investigated
  \[ \frac{\exp(\text{cover})}{1+\exp(\text{cover})} = B_0 + B_1X_1 + B_2X_2 \ldots + B_nX_n \]

• Simplicity: tree attributes, then stand attributes, then climate

• AICc to select multiple potential models, RMSE to compare accuracy
Regression model variables

- Stocking (raw, socially-adjusted, capped, or both)
- Crown width (R6; raw, socially-adjusted, capped, or both)
- Stand Density Index (uneven-age, raw, socially-adjusted)
- Basal area
- Tree density by diameter class or height class
- Stand height
- Stand age
- Site productivity (CMAI)
- Quadratic mean diameter
- Precipitation
- Elevation
Plots grouped by forest type

West-side groups (main types)

• Wet conifer: Douglas-fir, w. hemlock, redcedar, Pacific silver fir
• Dry conifer: grand fir, incense-cedar, Ponderosa pine
• Wet hardwood: red alder, bigleaf maple, Oregon ash, cottonwood
• Dry hardwood: Oregon white oak, tanoak, madrone

East-side groups (main types)

• E-dry: Ponderosa pine, western juniper, Oregon white oak
• E-high: lodgepole pine, mountain hemlock, Engelmann spruce
• E-mesic: Douglas-fir, white fir, western larch, quaking aspen
Stocking and crown width were best predictors of cover.
# Model results

(positive effects, *negative effects*)

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<th>AICC</th>
<th>w</th>
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Predicted canopy cover at different levels of stddbh and CMAI—all OR non-climate model
Conclusions 1

• Simple summations of tree-level calculations did not match cover measurements well
• The best regression models used crown width estimates with adjustments for social position and caps at 100% by stand position
• SDI didn’t do too well.. was it lack of species coefficients? Inability to cap and adjust for overlap?
• The best models used climate variables, but the RMSE’s of the models without climate variables weren’t much larger
Conclusions

• Trees in dry and mesic forests appear to fill crown space differently, but not clear how best to incorporate different overlap functions

• RMSE’s likely ~high from variable radius plot sample error, but regression parameter values should be appropriate

• Missing data from older forests→new data?
Questions or comments?