Proceedings of the 7th International Conference on Functional-Structural Plant Models, Saariselkä, Finland, 9 - 14 June 2013. Eds. Risto Sievänen, Eero Nikinmaa, Christophe Godin, Anna Lintunen & Pekka Nygren. http://www.metla.fi/fspm2013/proceedings. ISBN 978-951-651-408-9.

Testing a radiation transmission model for stands consisting of individual 3D Scots pine and silver birch trees

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Highlights: Model-based estimation of light transmission showed acceptable precision in stands, which were reconstructed in 3D using basic tree-level forest inventory variables as input. It appears possible to limit the time costs of computation by restricting the number of sky sectors for ray tracing of light in the model.

Keywords: boreal forest, crown architecture, light transmission, mixed stand, tree structure

We have earlier designed models to reconstruct the 3D crown structure for Scots pine and silver birch using basic tree level input variables: tree height, crown height, diameter at breast height, and the degree of competition estimated with simple indices (Lintunen et al. 2011). Here we assessed the precision of estimating the transmission of photosynthetically active radiation (PAR) within mixed stands constructed in the LIGNUM-system using the 3D trees generated with the models. We measured PAR in field plots on fully overcast days and then estimated the corresponding levels of PAR using equivalent model-generated plots (Fig. 1). In total, 26 field measured 3D plots consisting of 3m to 15m tall tree individuals were reconstructed within 5m around the plot centre. The border forest surrounding the reconstructed plot was modelled as a homogeneous stand with its species-specific LAI and crown layer depth adopted from the reconstructed 3D trees. PAR reaching the measurement point was calculated using a range of 12 to 360 sky sectors with their brightness derived from the radiation distribution of the standard overcast sky. Shading was calculated by backward ray tracing of light paths from the sample position towards each sky sector. Light transmission in the border forest was calculated with the Beer-Lambert law. The results were analysed using the amount of PAR standardized with respect to PAR at an open site. The maximum fit with model-predicted PAR (r^2 = 0.63) was obtained when only 12 light paths were used (Fig. 2). The fit was poorer (r^2 = 0.54) if a fully homogeneous stand was used instead of including 3D trees. Good fit with only 12 light paths shows potential to restrict the time costs of computation required to estimate light transmission in spatially explicit stand models where short-term PAR on overcast days can serve as a surrogate variable to drive growth.

LITERATURE CITED

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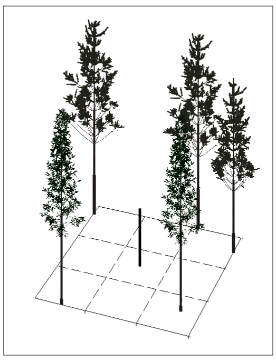

Fig. 1. The model was used to predict PAR measured on the top of the black bar in the middle.

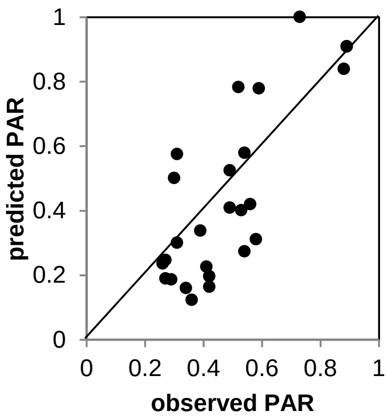

Fig. 2. Comparison of predicted and field-measured PAR.