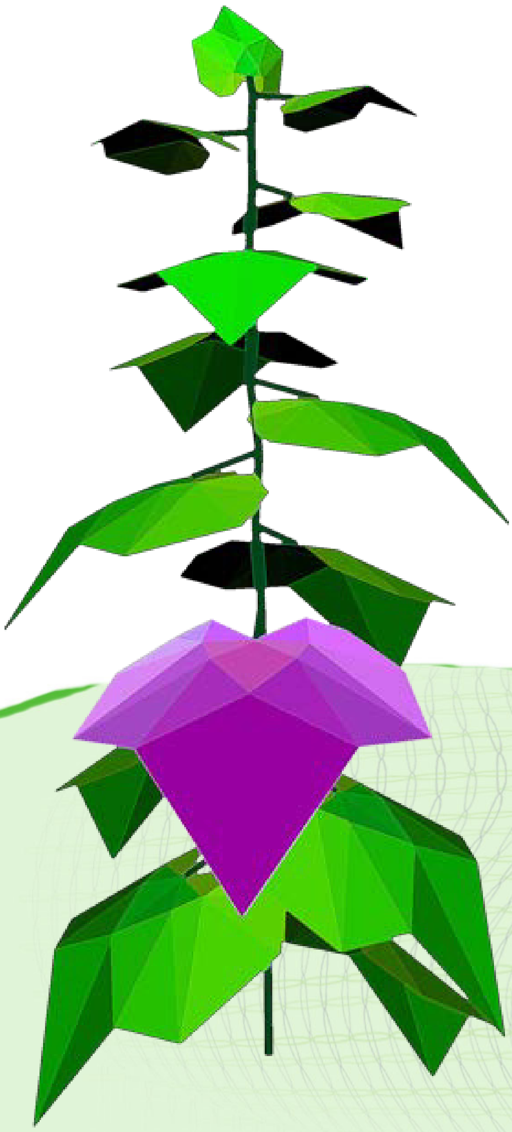
Book of Abstracts

Editors
Katrin Kahlen
Tsu-Wei Chen
Andreas Fricke
Hartmut Stützel



FSPM2020:

Towards Computable Plants

9th International Conference on
FUNCTIONAL-STRUCTURAL PLANT MODELS
5-9 October 2020

Book of Abstracts of the 9th International Conference on Functional-Structural Plant Models: FSPM2020, 5 - 9 October 2020. Eds. Katrin Kahlen, Tsu-Wei Chen, Andreas Fricke & Hartmut Stützel.

https://www.fspm2020.net

Editorial office:

Institute of Horticultural Production Systems
Herrenhäuser Strasse 2
30419 Hannover
Germany

tel.: +49-511 762 2638

e-mail: fspm2020@gem.uni-hannover.de

Modelling shade cast by rows of trees using 3D models based on terrestrial laser scanning data

Rafael Bohn Reckziegel[1], Jonathan P Sheppard[1], Christopher Morhart[1], Ben du Toit[2], Hans-Peter Kahle[1]

[1] *Chair of Forest Growth, University of Freiburg, Freiburg im Breisgau, Germany*
[2] *Department of Forest and Wood Science, Stellenbosch University, Stellenbosch, South Africa*

For correspondence: rafael.bohn.reckziegel@iww.uni-freiburg.de

Keywords: shadow model, LiDAR, agroforestry, windbreak, *Alnus cordata*

Introduction

The establishment and utilization of trees within an agricultural setting has both traditional roots and modern-cutting-edge applications for increased benefits in terms of productivity and other ecosystem services. In order to understand the functioning and interplay between trees and crops within agroforestry systems (AFS), it is important to investigate the interactions of the AFS components with regard to the utilization of water, nutrients and light. The availability of incoming solar radiation, while considering its temporal and spatial distribution is largely dependent on the spatial and functional structures that are present in the field. This issue is of high significance in AFS, and understanding such interactions is essential to improve, effectively plan and manage these integrated land-use systems. Targeting an enhanced simulation of the shade cast by trees within AFS, we apply a tested approach that utilises a 3D model capable of quantifying tree shading at a high temporal and spatial resolution. This procedure allows for the modelling of the shade dynamics in the vicinity of single trees as well as groups of trees, such as in windbreaks.

Here, the use of this technique on windbreaks consisting of multiple aligned alder trees (*Alnus cordata*) is presented in a southern African context. The application of an approach modelling the shade cast by windbreaks, distinguishes the current work from others.

Materials and Methods

The study site utilised alder trees planted in rows as windbreaks, surrounding various berry species (*Rubus* spp.) within a fruit farm near Stellenbosch, South Africa (33°54.4'S 18°56.7°E; 404 m a.s.l.). The study site experiences a Mediterranean climate (rainy winters and dry summers) with mean maximum and minimum annual air temperatures of 22.3 and 12.5 ˚C respectively. The study site boasts a mean annual precipitation sum of approximately 934 mm, with an average of 80 rain days (≥1 mm) per year. With respect to crop production, water limitation is an issue in summers.

The windbreaks were scanned with the RIEGL VZ 2000i, a terrestrial laser scanner (TLS) in September 2019, under leaf-off conditions to reduce occlusion of the tree crown and to increase the accuracy of scanning. At the time of scanning, the target trees had heights ranging between 4 and 16 m, a diameter at breast height of between 7 to 26 cm and were 15 to 20 years old. Trees were located in rows with a spacing of approximately one metre between trees.

Point clouds derived from TLS were postprocessed, filtered, and downsampled. Single-tree point clouds were manually segmented and cylinder models were computed using *TreeQSM* (Raumonen et al. 2013). Number of cylinders was reduced to a maximum of 3000 cylinders per tree model, as a means of reducing required computational effort in the shadow simulations. Finally, cylinder models of single trees were combined with neighbouring trees, representing actual spatial arrangement in the field.

An enhanced version of the algorithm developed by Rosskopf et al. (2017), implemented in the free software environment R (version 3.5.3), was used to calculate the shade cast using the derived cylinder models. Solar irradiance data for September 2019 (Stellenbosch University, 2020) was utilised to quantify the resultant deficit of solar radiation energy on the ground due to the shading effect of the trees.

Results and Discussion

The chosen approach allows the utilisation of 3D point cloud data of groups of windbreak trees to compute shade cast projections at a high level of temporal and spatial resolution in southern African landscapes. The derived model provides tree shade cast projections of multiple trees in 10 minutes time intervals for a raster grid with a cell size of 10 cm x 10 cm. Leaves were not incorporated in the modelling at this stage due to their inherent complexity and increase in processing time; this represents a future goal in the modelling of shade for multiple trees.

Based on our approach, the monthly shade cast by four sample windbreaks was modelled for the entire month of September 2019. The shade cast by one windbreak section consisting of five alder trees, for a 10 minutes interval, is shown in Figure 1.

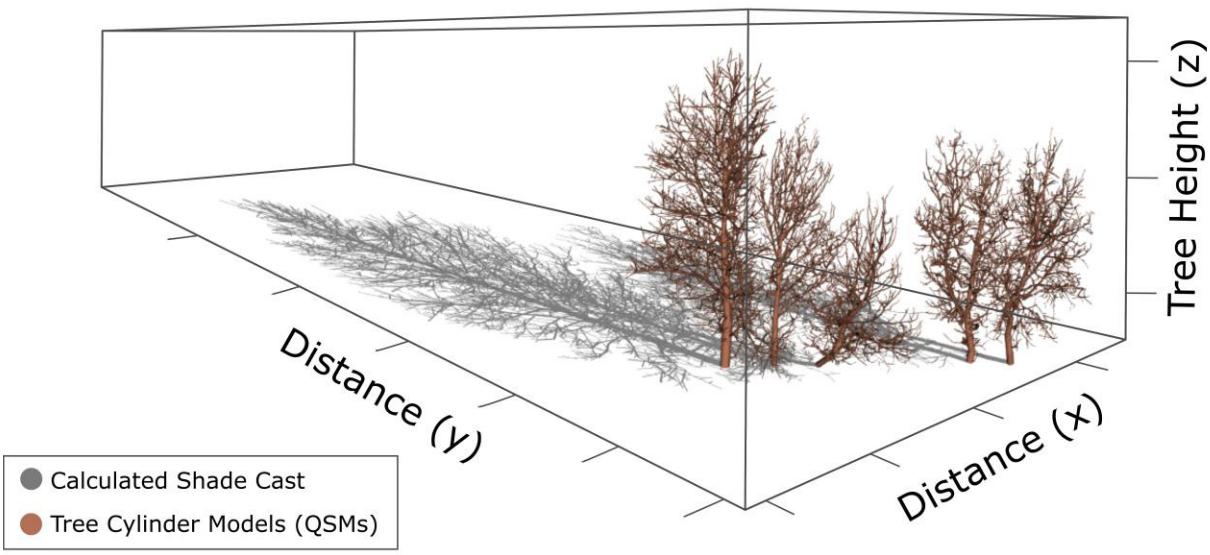


Figure 1: Computed shade cast for a ten minutes interval of a windbreak section consisting of five alder trees near Stellenbosch, South Africa (33°54.4'S 18°56.7°E; 404 m a.s.l.).

Conclusion

The use of 3D point cloud data coupled with actual solar irradiance data provides the possibility to accurately and effectively model the shade cast by groups of trees. This approach allows land managers to effectively plan their operations by either managing windbreak dimensions to minimise shading effects or to plant shade tolerant species in highly shaded areas of the field.

References

Rosskopf et al. 2017, *Remote Sensing*, *9, 719,* doi: 10.3390/rs9070719
Raumonen et al. 2013, *Remote Sensing*, 5, 491-520, doi:10.3390/rs5020491
Stellenbosch University, 2020. Stellenbosch Weather – Sonbesie station [Online] http://weather.sun.ac.za/ [accessed 1 April 2020]