
Three-Dimensional model-based analysis of the impact of variability in almond tree structure and configuration

Project No.: HORT45.Bailey

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A. Summary

This project proposes to develop and use state-of-the-art modeling tools to quantify and predict interactions between almond tree traits (phenotypes) and environmental conditions. The scope of this three-year project focuses more specifically on tree growth, structural development, and yield dynamics as it pertains to canopy configuration and architecture. The modeling framework will represent tree development in three-dimensions, explicitly representing every leaf and branch as it evolves in time (Figure 1). This approach allows for direct representation of the effects of inter- and intra-crown competition for resources such as light, and how it drives shoot growth and spur dynamics.

The overall goal of this project is to develop a detailed, three-dimensional modeling framework that can inform breeding and selection practices by predicting how tree structure and growth/yield dynamics vary in response to variability in genotypes, management, and orchard configuration. The model will then be used to determine optimal tree structures that maximize yield over the lifespan of an orchard. This project fits within a wider vision of incorporating next-generation models within the modern breeding pipeline to accelerate the rate of new cultivar development and assessment.

At the time of writing this report, the project was in its first several months since its beginning, and thus only initial planning and preparatory work has been initiated. Ongoing work is focused on Objectives 1 and 2 as laid out below.

B. Objectives

Objective(s)	Date to be accomplished	Milestones and deliverables associated to the objective
1. Collect phenotypic data for model parameterization	October 2022	Two seasons worth of biweekly data collected in orchards of three contrasting cultivars, which will provide the data needed to parameterize models.
2. Develop and validate improved models to predict the 3D development of canopy structure, spur dynamics, and yield	October 2022	Ability to realistically simulate yield curves throughout the lifespan of an orchard for variable cultivars, climates, and orchard configurations.
3. Determine optimal tree architectures for various orchard configurations, and quantify the associated potential yield gains	July 2023	Determination of optimal theoretical almond tree structure and associated orchard configuration that maximizes yield; Analysis of how architectural differences of Nonpareil, Winters, and Wood Colony affect light distributions and yield.

C. Annual Results and Discussion

No significant results to date, as project only recently began (discussed above).

D. Outreach Activities

No outreach to report, as the COVID-19 pandemic and short timeline have prevented any such outreach.

E. Materials and Methods:

N/A

F. Publications that emerged from this work

Manuscripts in preparation:

Bailey, B.N., and Kent, E.R. On the resolution requirements for representing interactions between plant canopy structure and function in three-dimensional leaf-resolving models.

Kent, E.R., and Bailey, B.N. Can Multiple-Return Terrestrial Laser Scanning Data Improve Leaf Area Density Estimates?

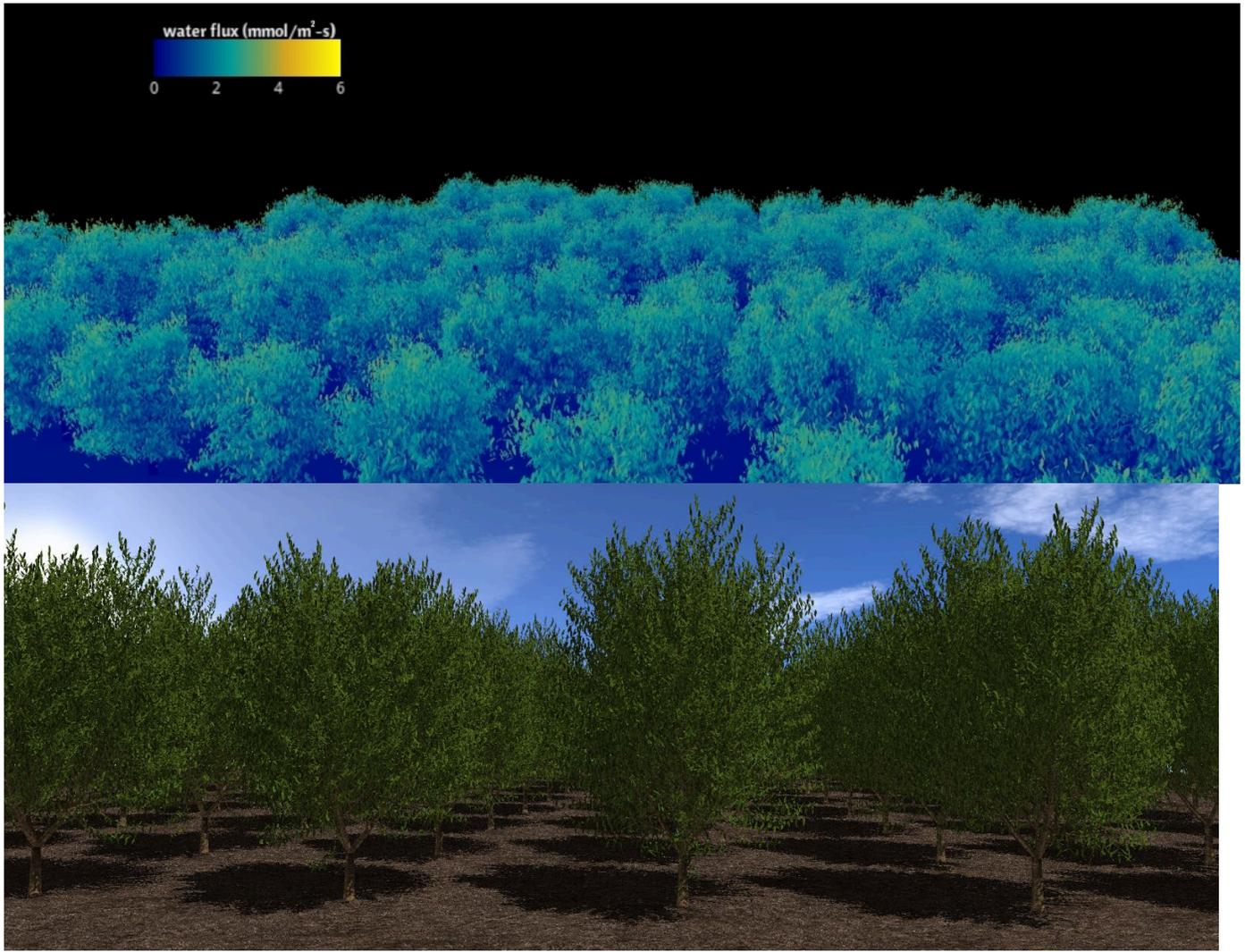


Figure 1. Top: Simulation of transpiration flux in an almond orchard. The orchard was scanned using ground-based LiDAR and reconstructed using the algorithms developed by the PI. The energy balance was then solved for every surface in the canopy using Helios to provide leaf-level predictions of the transpiration flux. Bottom: Almond orchard produced from a procedural tree generator, which explicitly represents structural linkages between branches, leaves, etc.