Developing a Carbon Budget, Physiology, Growth and Yield Potential Model for Almond Trees

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Objectives:
This project has two major objectives. The first is to collect research data on almond (and related species) tree growth; biomass productivity; dry matter partitioning; and carbon assimilation, utilization and distribution. These data will then be used to estimate the amount of carbon sequestered in the standing biomass of almond orchards as well as to provide data for validating the long-term biomass accumulation projections of the L-Almond model that is being developed in the second objective.

The second and longer-term objective of this project is to develop a comprehensive functional-structural tree model (L-Almond) of almond tree architectural development and growth, carbon partitioning/source sink interactions, annual and multi-year carbon budgets and yield potential of almond trees. This model will simulate growth and physiological responses to light distribution within the canopy and daily temperature and water potential changes as well as respond to user imposed pruning practices.

Developing the L-Almond Model:
The primary work of converting the L-Peach model to an L-Almond model was to adjust leaf photosynthetic characteristics, fruit growth patterns and the statistical models of shoot bud fates of Nonpareil almond into the L-Peach model. This work has been completed and a preliminary version of the L-Almond model was completed last year. During the development process of L-Almond we realized that our annual carbohydrate storage and spring remobilization sub-model was not providing realistic simulations. Consequently we made substantial efforts during this year to correct this deficiency (this research was not trivial since no other tree simulation model has adequately addressed this problem previously). We believe we have solved this problem.

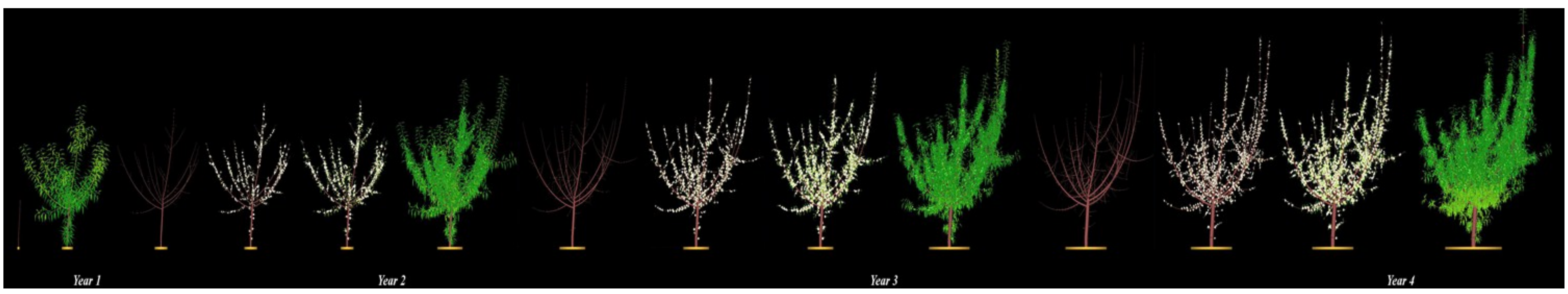


Figure 1. Simulated virtual almond trees produced by the L-Almond model. These renditions are preliminary images depicting four years of growth of young almond trees. Year 1 are trees growing in the nursery. The trees were pruned in the computer during the simulated dormant season between each year but minimal pruning was done between years 3 and 4. The architecture of the trees was developed according to bud fate models developed for Nonpareil almond. Additional research is now required to test the outputs of the model and improve the accuracy of the physiological functioning according to data available from field experiments.

Interestingly, the L-Almond model has identified an underappreciated, critical period during fruit growth and development that may be a major determinate of final yield. This is the period of fruit drop after pollination but before shell hardening. While this fruit drop has been a concern to growers for many years, the cause of this fruit drop has not been clear. The model indicates that this fruit drop is likely caused by a lack of carbohydrates available to support fruit growth during a critical period when vegetative and reproductive growth transitions from dependency on stored carbohydrates to current photosynthates. Additional field research is necessary to confirm this but the model can be used to pinpoint critical periods that must be studied in the field.

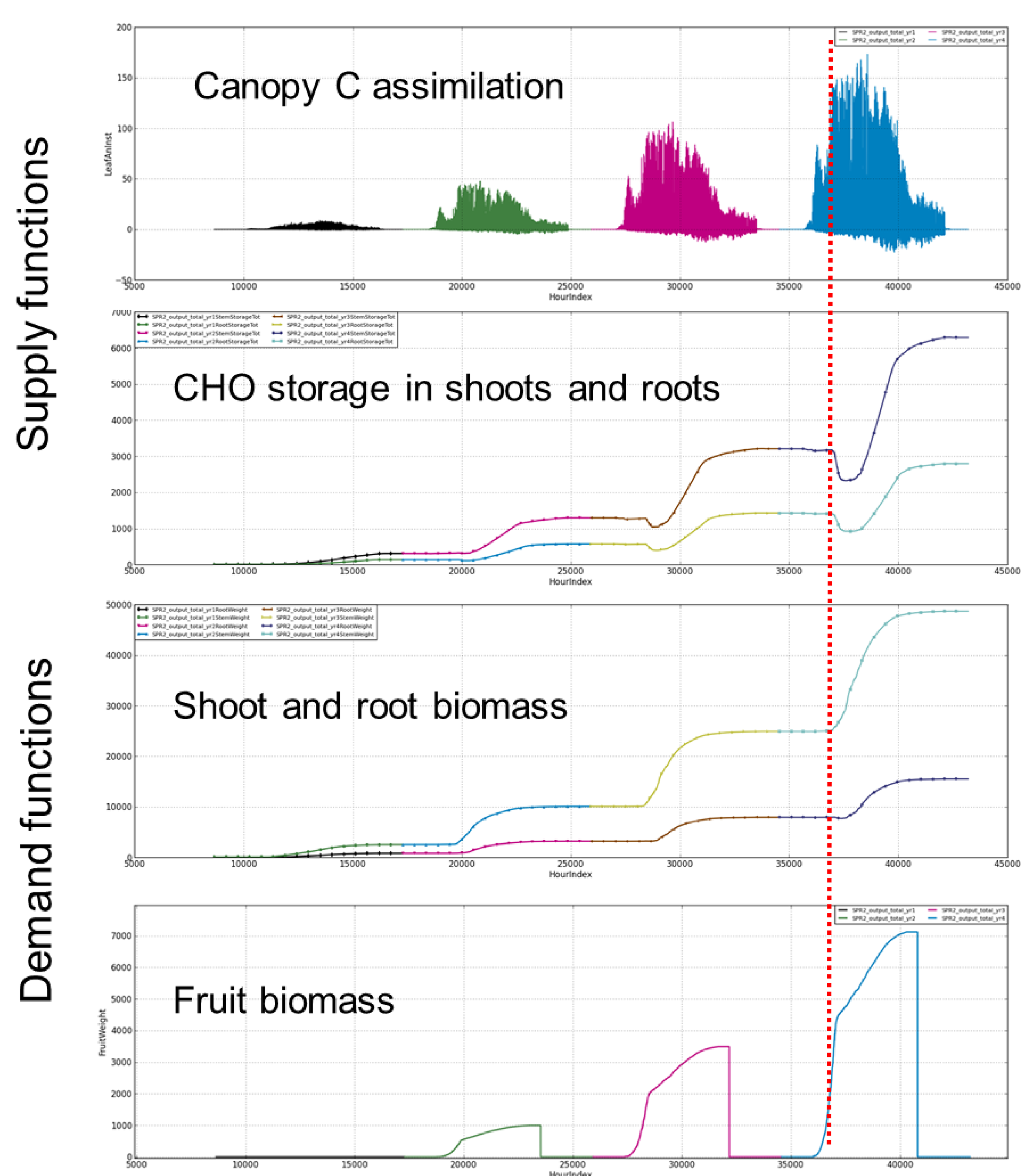


Figure 2. Simulated patterns of tree carbohydrate supply and demand functions over four years. Vertical bar indicates critical period of potential assimilate limitation.

Empirical estimation of standing biomass in almond:
We have been working with professional orchard removal companies to obtain data on the weight of chippings obtained during the removal of an orchard. Last year we reported that data from 61 removed orchards representing 2034 acres indicated that orchard biomass varies greatly among orchards. In this set of removed orchards the amount of dry biomass removed varied from 4 to 63 dry tons per acre with the mean and median dry tons per acre removed being 27.7 and 26.3, respectively.

In light of this large variation in orchard standing biomass we began to investigate methods to survey orchards to estimate standing biomass based on combining measured mean trunk diameter data and biomass data from orchard removal. This involves cooperative work between an orchard removal company (GF Ag Services LLC. Ripon), and UC researchers (DeJong and Lampinen labs, UC Davis).

This year we surveyed about 40 orchard removal sites prior to tree removal and collected tree trunk diameter data on several rows of trees across the orchard in order to estimate the mean tree trunk cross sectional area (TCSA) per acre and the total TCSA per site. We now have TCSA and biomass data on about one-half of the sites surveyed. As anticipated, our preliminary data (from less half of the surveyed sites) indicates that there is a good correlation between estimated TCSA per acre and the amount of biomass removed per acre (Figure 3, 4). During the next few months we will obtain removed biomass data on 20 more sites and determine if we can further refine the relationships by using Google Earth images to account for missing trees and verify reported orchard acreage removed.

Figure 3.

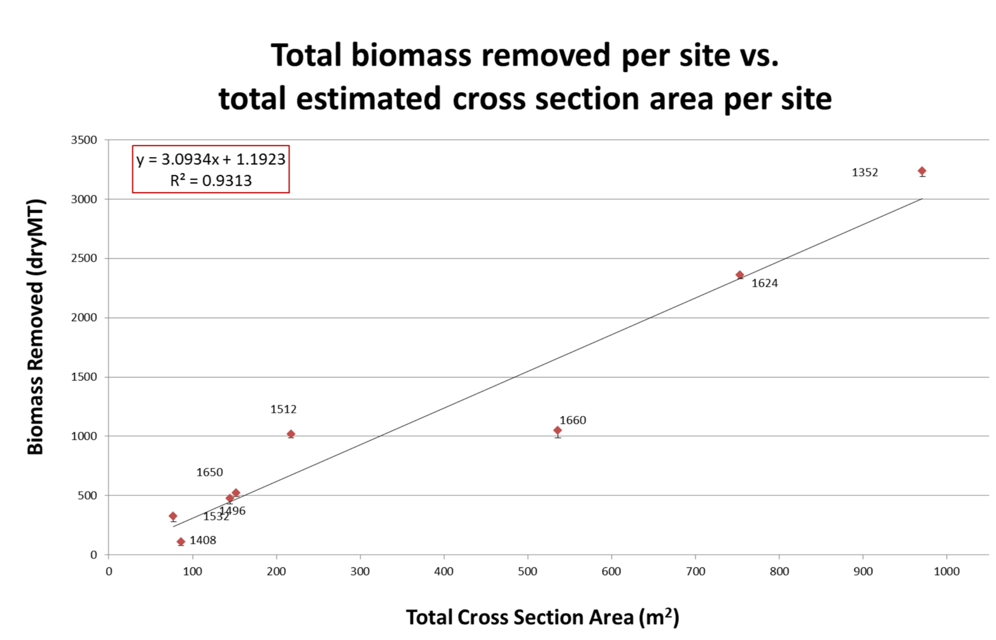
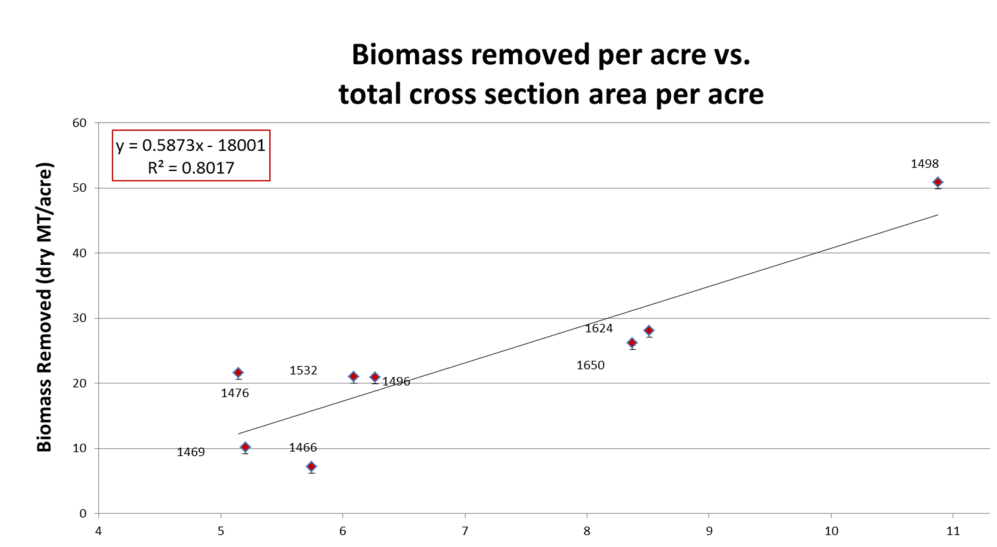


Figure 4.



Publications resulting from this research. A corollary effort associated with this project has been the analysis of data from the Regional Variety trials sponsored by the Almond Board (1993-2005) and from the spur dynamics study carried out by Dr. Lampinen's laboratory from 2001 to 2007, in order to develop an understanding of factors controlling bearing and long-term spur behaviour needed for developing and validating the L-Almond model.

Fruit development in almond is influenced by early Spring temperatures in California
S. Tombesi, R. Scalia, J. Connell, B. Lampinen and T.M. DeJong
***Journal of Horticultural Science and Biotechnology* (2010) 85:317-322.**
Data from this paper have been used to develop a web-based model to help growers predict hull-split in their orchards by late May of each year.
See: Hull-split Prediction Model at http://fruitsandnuts.ucdavis.edu/Weather Services/

Spur behaviour in almond trees: relationships between previous year spur leaf area, fruit bearing and mortality
Bruce D. Lampinen, Sergio Tombesi, Samuel Metcalf and Theodore M. DeJong
***Tree Physiology* (2011) 31: 700-706**

Relationships between spur- and orchard-level fruit bearing in almond (*Prunus dulcis*)
Sergio Tombesi, Bruce D. Lampinen, Samuel Metcalf and Theodore M. DeJong
***Tree Physiology* (2011) 31: 1413-1421**

Relationship between spur fruit set and spur leaf dry weight in almond.
Sergio Tombesi, Bruce D. Lampinen, Samuel Metcalf AND Theodore M. DeJong
***Tree Physiology* (submitted)**

In addition, this project supported the completion of Dr. Claudia Negron's Ph.D. dissertation titled: "Branching and Flowering Patterns of Almond Shoots: A Modeling Approach"