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. Since we reported on this aspect of the project last year, this year we will focus on the second objective ; development of the L-Almond model.

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 second objective (developing a model of almond tree growth by converting the L-Peach model) began with statistically analyzing the structural patterns of various sizes of almond shoots using Hidden Semi-Markov Chain (HSMC) analysis techniques (Guedon et al. 2001). This work began in 2010 in a commercial 4-year-old almond orchard located near Sutter. Detailed analysis of shoot structural changes in Nonpareil almond in response to water stress and pruning were also conducted. Details of the procedures used in these studies are contained in previous reports. All of this research has now been completed and manuscripts reporting this work have been submitted to scientific journals.

The shoot structural models have been incorporated into the new L-Almond computer simulation model and we began to validate the architectural aspects of simulated trees with pictures of actual orchard trees of various ages. However we ran into difficulties with doing simulations of tree growth over periods longer than three years in almond trees because running simulations according to current grower practices required not pruning after the first year. This caused the tree structure to become too complex because all shoots were maintained indefinitely. To address this we have incorporated a new canopy light distribution program into the model and also have developed a new sub-model for the shedding of leaves and stems that are located in the excessively shaded areas of the canopies. We are now beginning to test the functioning of the leaf and stem shedding functions. These leaf and stem shedding functions simulate what occurs naturally in trees when the lower central volume of a tree canopy becomes shaded and small shoots and spurs die out. We are now in the process of further validating the performance of the model by attempting to run simulations of up to 10 years of tree life.

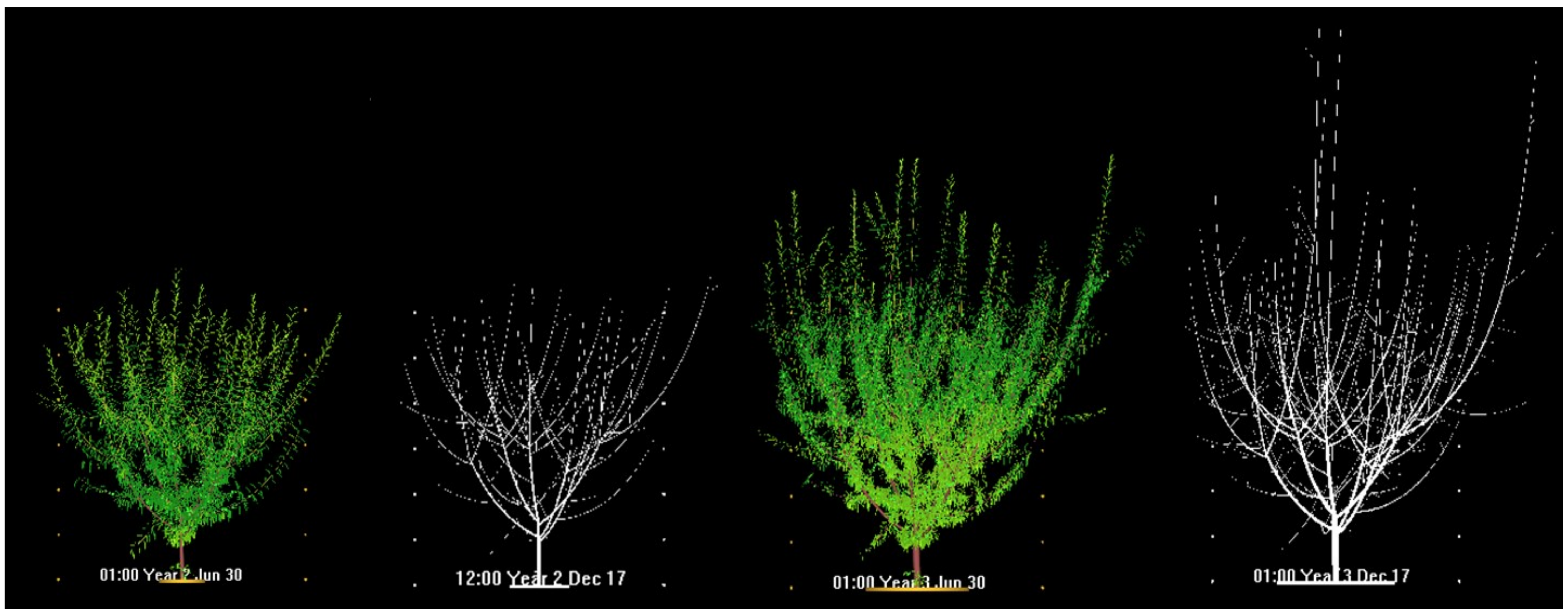

Fig. 1. Simulated trees during the 2nd and 3rd year after planting the orchard. Scaffold selection and light heading was done at the end of the 1st year but no subsequent pruning was done.

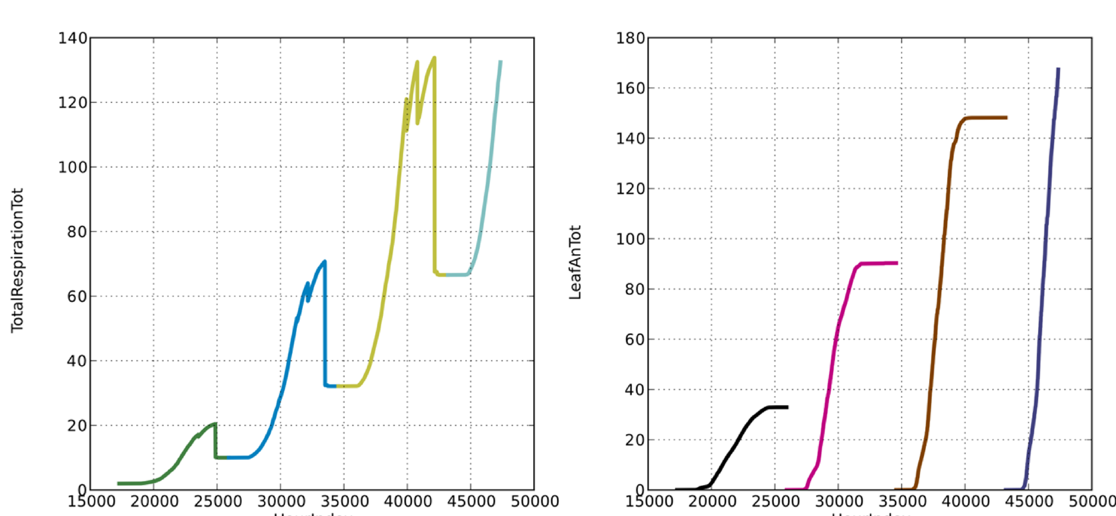

Fig. 2. Simulated whole tree respiration and photosynthesis for years 2 – 4.5 of tree growth

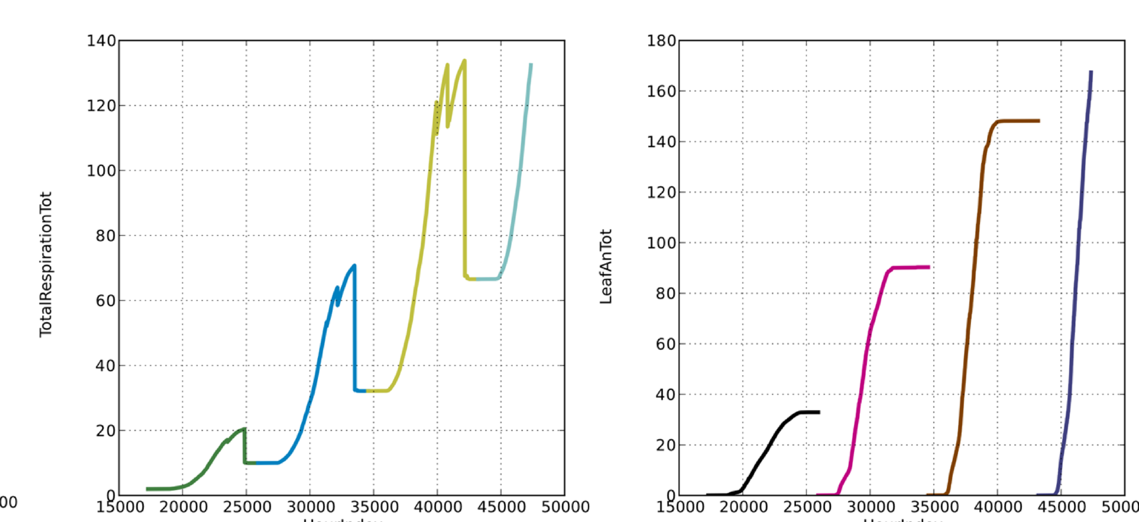

Fig. 3. Simulated number of stems segments (internodes) and stem biomass for years 2 – 4.5 of tree growth. Note: The decrease in number of stems is a result of heavy shading in the center of the canopy but their loss does not significantly affect total stem biomass because they are so small.

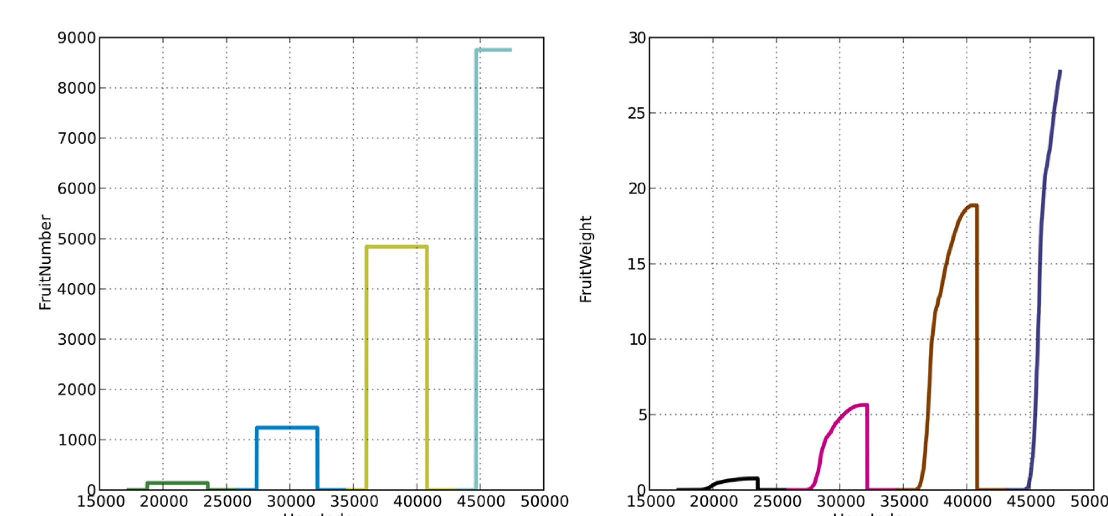

Fig. 4. Simulated number of fruits and total fruit dry weight for years 2 – 4.5 of tree growth.

Publications resulting from this research and research associated with this project. There have been three lines of research associated with this research that have resulted in published research papers.

1. 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. This was done to develop an understanding of factors controlling bearing and long-term spur behaviour needed for developing and validating the L-Almond model.

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

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

Spur fruit set is negatively related with current year spur leaf area in almond. S.Tombesi, B. D. Lampinen, S. Metcalf and T. M. DeJong *(submitted for publication)*

2. Analysis of structure of almond shoots and spurs to develop statistical shoot structural models that can be inserted into the L-Almond functional structural growth simulation model.

Systematic Analysis of Branching Patterns of Three Almond Cultivars with Different Tree Architectures. C. Negron, L.Contador, B. D. Lampinen, S. G. Metcalf, Y. Guedon, E. Costes and T. M. DeJong. *J. Amer. Soc. Hort. Sci.* (2013) 138(6):407–415. 2013.

Differences in proleptic and epicormic shoot structures in relation to water deficit and growth rate in almond trees (*Prunus dulcis*). C. Negron, L. Contador, B. D. Lampinen, S. G.Metcalf, Y. Guedon, E. Costes and T. M. DeJong. *Annals of Botany* (2014) 113:545-554.

How different pruning severities alter shoot architecture: A modelling approach in young 'Nonpareil' almond trees. C Negron, L. Contador, B. D. Lampinen, S.G.Metcalf, Y. Guedon, E. Costes and T. M. DeJong. *Functional Plant Biology* (2014) In Press

3. Studies related to dormancy chill and bud break of California nut crops.

Nut crop yield records show bud break based chilling requirements may not reflect yield decline chill thresholds. K.S. Pope, V. Dose, D. Da Silva, P.H. Brown and T.M. DeJong . *International Journal of Biometeorology* (2014) DOI.1007/s00484-014-0881-x.

A biologically based approach to modeling spring phenology in temperate deciduous trees. K.S. Pope, D. Da Silva, P. H. Brown and T.M. DeJong. *Agricultural and Forest Meteorology 198-199 (*2014) *15–23*