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:

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. 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).

We have surveyed orchard removal sites prior to tree removal and collected tree trunk diameter data on several rows of trees across the orchards 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 several of the sites surveyed. As anticipated, our preliminary data indicates that there is a good correlation between estimated TCSA per acre and the amount of biomass removed per acre (Figure 1, 2). During the next year we will obtain removed biomass data on 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 1.

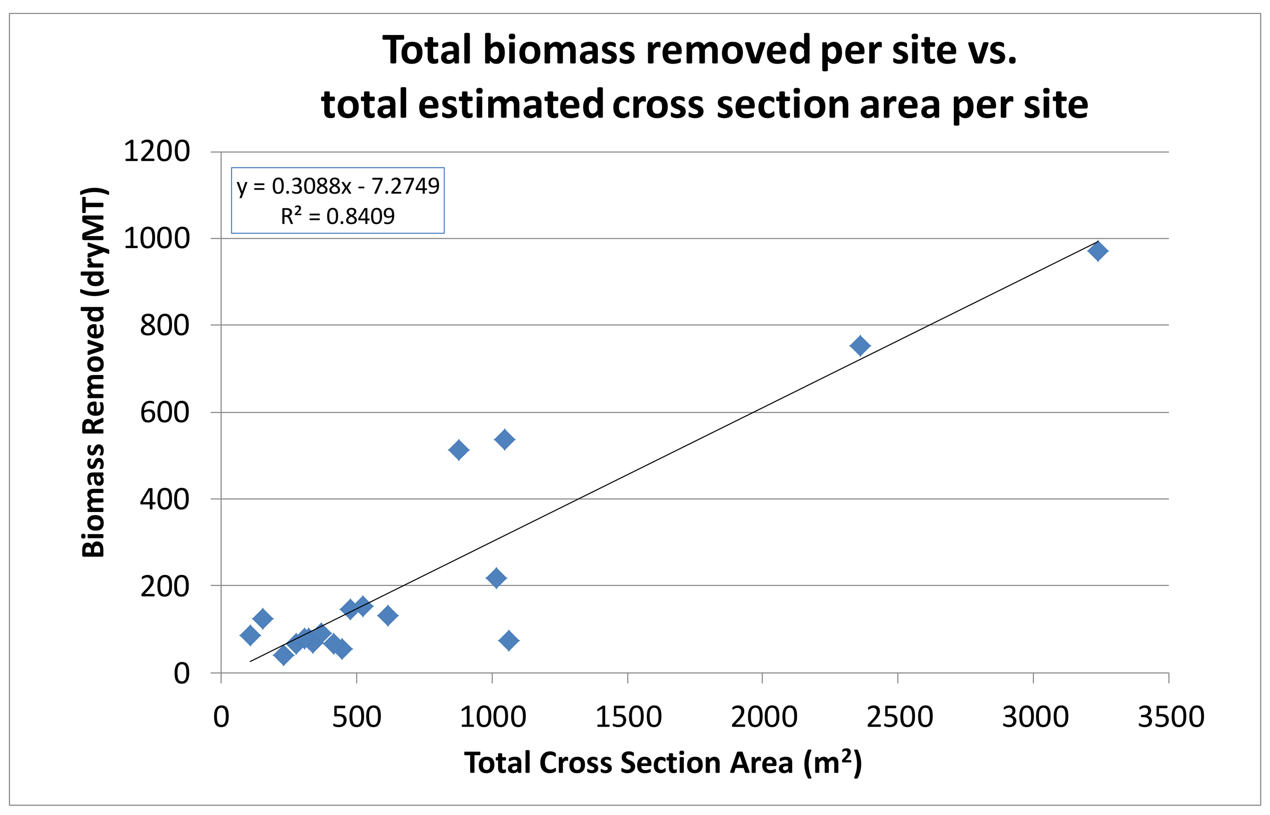
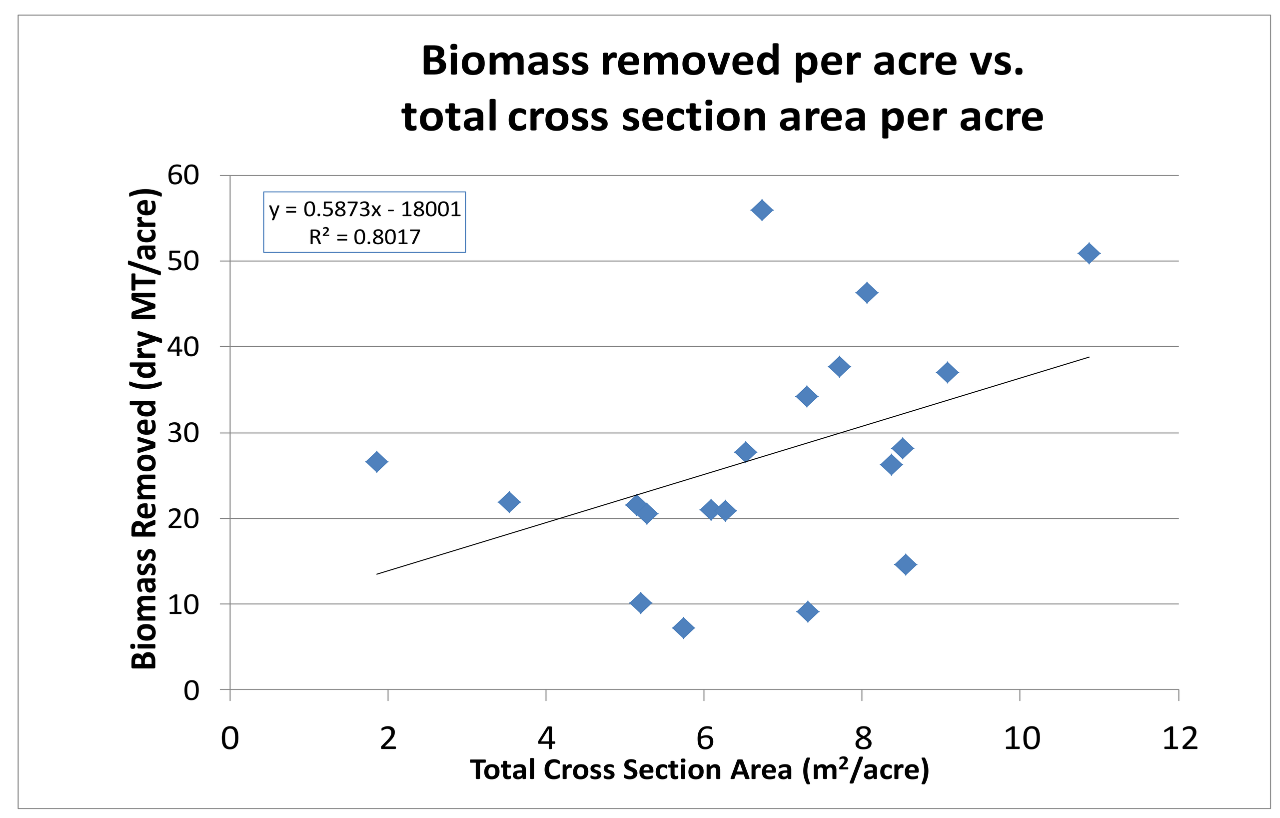


Figure 2.



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 are in the process of validating the outputs of the model with empirical data. However, we have run into difficulties in running the model beyond four years because of computational capacities and are currently consulting with computer scientists to address this issue.

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. 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

Relationships between spur flowering, fruit set, fruit load and leaf area in almond trees. Sergio Tombesi, Bruce D. Lampinen, Samuel Metcalf and Theodore 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. Claudia Negron, Loreto Contador, Bruce D. Lampinen, Samuel G. Metcalf, Yann Guedon, Evelyne Costes and Theodore 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*). Claudia Negron, Loreto Contador, Bruce D. Lampinen, Samuel G.Metcalf, Yann Guedon, Evelyne Costes and Theodore M. DeJong. *Annals of Botany* (in press)

How different pruning severities alter shoot architecture: A modelling approach in young 'Nonpareil' almond trees. Claudia Negron, Loreto Contador, Bruce D. Lampinen, Samuel G.Metcalf, Yann Guedon, Evelyne Costes and Theodore M. DeJong. (submitted for publication).

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

Nut crop yield records show misconception of the significance of bud break based chilling requirements. K.S. Pope, V. Dose, D. Da Silva, P.H. Brown and T.M. DeJong