Carbon Dynamics of Applying Chipped Almond Prunings to the Orchard Floor as Affected by Soil Type and Management Practices

11-STEWCROP4

Background & Purpose

There is widespread interest in better understanding and quantifying the effects of different pruning practices on the carbon (C) balance of agroecosystems as California faces cap and trade regulations of greenhouse gas (GHG) emissions and air quality legislation focused on burning activities. This project investigates the influence of applying chipped almond tree prunings to the orchard floor, as an alternative to burning, on soil C. The work will also summarize management strategies and the successes and challenges of chip application. The recent industry trend of chipping (instead of burning) annual prunings and trees from orchard removal, and leaving them to decompose on the orchard floor could improve soil quality and almond production by increasing organic matter and moisture holding capacity of orchard soils. Additionally, this alternative to burning could improve air quality and move the almond industry closer to state and federal air quality compliance. This project builds on previous research focused on the soil effects of applying chips of both prunings and whole-tree residues in the San Joaquin Valley.

The purpose of this project is to improve the industry understanding of how pruning management techniques influence soil C stocks. Employing a statewide approach, the project will take into account important regional and sub-regional differences in soil types, irrigation methods, between-row vegetative covers, and orchard-management practices. These rank as the key factors that influence C flux associated with applied prunings and the effective management of this process. Given the statewide scale of annual prunings disposal (about 400,000 tons) and orchard removal, this project may not only enhance the state's production of almonds, but may also have practical application for other valley-wide improvements to air quality. This project addresses ever-increasing regulatory pressures on growers and aims to reduce GHG emissions, increase soil C and organic matter reserves, optimize between-row vegetation management, and improve soil moisture relationships in almond production.

Objectives

Project objectives are designed to encompass actual field practices, available literature, ongoing research and the latest in modeling efforts to:

- Review almond field pruning and chipping practices statewide
- Summarize existing research on pruning management impacts of soil C and net GHG emissions
- Provide input parameters to the DeNitrification/DeComposition (DNDC) GHG soil biogeochemical model
- Build GIS and remotely sensed databases on soils, climate and orchard management, orchard location, irrigation systems, etc.
- Ascertain C sequestration opportunities and losses associated with applying chipped almond prunings to the orchard floor instead of historic burning
- Identify these opportunities and losses on a regional basis, covering the range of almond orchard conditions and pruning management in California
- Determine whether chip application results in a valuable accumulation of soil C in otherwise low organic matter soil systems
- Develop a validated version of the DNDC greenhouse gas soil biogeochemical model to serve as a specialized management tool for California almond producers

Timeline

2 Year Project Timeline

Description	Q1 Oct-Dec 2010	Q2 Jan-Mar 2011	Q3 Apr-Jun 2011	Q4 Jul-Sept 2011	Q5 Oct-Dec 2012	Q6 Jan-Mar 2012	Q7 Apr-Jun 2012	Q8 Jul-Sept 2012
Initiate project with kick-off workshop	■							
Prepare GIS maps for almond acreage by county and soil type.	■	■	■	■				
Conduct field survey of growers and state-wide experts.		■	■	■	■	■		
Conduct comprehensive literature review.			■	■	■	■		
Validate DNDC model.	■	■	■	■	■	■		
Summarize results of fields survey and literature review for DNDC model input .				■	■	■		
Conduct DNDC modeling.				■	■	■	■	
Build web-GIS version of DNDC model.					■	■	■	
Produce summary report.							■	■

Approach

The project approach includes field, literature, spatial representation and modeling-based evaluations, specifically:

Field Survey

- Conducted from April 2011 to March 2012
- Encompasses varying management practices across a variety of growing regions
- Includes growers, UCCE agents, academic experts, and industry professionals

Literature Review

- Includes all pertinent scientific literature and on-going research
- Guides the field survey
- Provides management input parameters for DNDC model

GIS Development

- Maps state-wide almond production
- Includes planting locations, soil types, climatic regimes, management practices, and planting densities

DNDC Modeling

- Developed specifically for almond orchards
- Predicts C dynamics and GHG flux in orchard soils
- Results in projections of improved C management

Reporting

- Documents research and modeling efforts
- Summarizes literature review and field survey results
- Includes recommendations for soil C management related to GHG emissions

DeNitrification/DeComposition (DNDC) Model

Denitrification and decomposition are two processes that dominate losses of nitrogen (N) and C from soil into the atmosphere. The development and validation of the DNDC model has been extensively applied to cropping systems throughout the world and is a leading resource for estimation of C and N management in cropping systems. The input, processes and output of DNDC are shown in Figure 1.

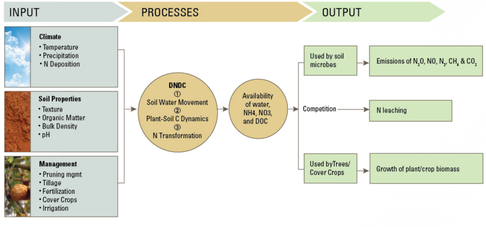

Figure 1 *Input, processes and output components of the DNDC model for bridging ecological drivers and GHG emissions*

The historic model development and validation has included:

- Development of the first model in 1990 with an initial focus on N_2O
- Model expansion to greater than 20 different crop modules, many specific to CA cropping systems
- Enhancement of modeling capabilities for CO_2, CH_4, N_2O, soil carbon dynamics and crop growth and yield estimations
- Rigorous model validation which is key for acceptance in both the scientific and market environments
- A requirement of appropriate field data for process-model validation
- Extensive validation from agro-ecosystems worldwide including over 100 peer review papers
- Modeling evaluations of multiple crops specific to California: Alfalfa, Almonds, Silage Corn, Cotton, Grapes (table and wine), Lettuce, Rice, Tomato and Walnut

DNDC validation and efforts specific to California crops include on-going projects and field measurements of N_2O emissions with researchers from UC Davis (Horwath, Six and Smart) and CSU Fresno (Goorahoo). Results of this project will create a validation set for almonds, specifically for woody vegetation (Figure 2). The DNDC model project tasks will include:

- Construction of an almond-specific growth model.
- Calibration of the model with field-specific parameters including soils, orchard densities, climatic regimes, pruning management, etc.
- Validation against observations from this effort and some funded by other projects.
- Running a 20 year model simulation across various prunings management options (burning, chipping with surface application and chipping with incorporation).
- Compilation of differences in soil organic C storage according to previously developed approaches and GHG emissions due to burning versus chipping/orchard floor application over the short and long-term.

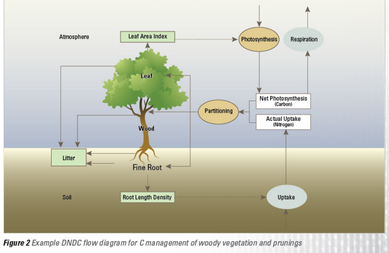

Figure 2 *Example DNDC flow diagram for C management of woody vegetation and prunings*

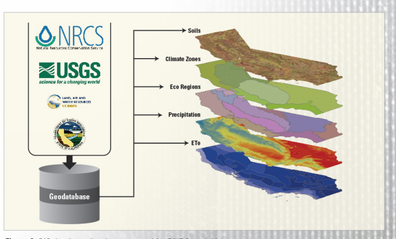

Figure 3 *GIS database development used for DNDC model inputs*

GIS data compiled, layered and analyzed (Figure 3) will be used as input parameters to the DNDC model. Almond acreage determined by remote sensing (Figure 4) will also be used in a pilot project as a DNDC input that is potentially more accurate than current sources of acreage. While remote sensing data for DNDC is relatively coarse, fine-scale mapping can also be accomplished using remote sensing.

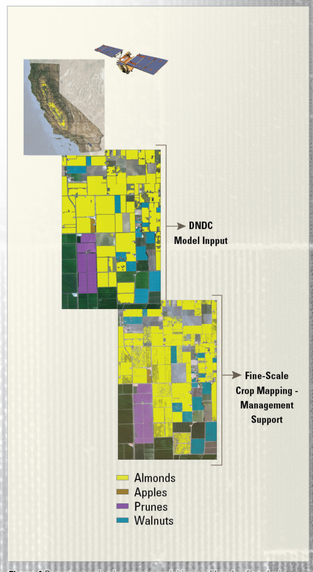

Figure 4 *Remote sensing imagery acquisition and levels of analysis*

Expected Results

The results of this project may improve the farming systems of more than 6,000 almond growers. Approximately 800,000 acres of almonds are currently produced in the Central Valley of CA at a value of over $2 billion. It is estimated that about 1,000 lbs/acre of prunings are removed annually. Given current acreage, the resulting 400,000 tons of burned prunings would lead to C losses and contribute further to existing air quality concerns in the San Joaquin Valley. This C-rich resource increases C supplies within orchard producing soils that are usually low in C reserves. The results of this study and modeling effort can likely be correlated to other annually pruned tree crops (e.g. walnuts, pistachios, peaches, prunes, etc.).

This project will result in significant measureable outcomes valuable to almond production state wide and also to several other tree crops with related practices. The project will provide:

- A comprehensive field review documenting the differences and interactions of between-row cover management, irrigation methods, soil type and associated orchard operational strategies influencing prunings management.
- A comprehensive literature review, coupled with on-the-ground observations will be instrumental in understanding differences across the state and provide support for suggested future research.
- A comprehensive, 20-year simulation modeling component will estimate the potential reduction in GHG emissions and quantification of soil carbon impacts of various prunings management strategies and the potential for enhanced C sequestration.
- Recommendations for chipped prunings management when applied back to the orchard floor as influenced by regional irrigation management, soils, between row vegetative cover management and general farming practices.
- Web-GIS modeling tool for quantification of soil C impacts and GHG emissions from various pruning management practices.
- Recommendations for in-field research approaches and variables most influential in C management of orchard floor applied prunings.

This project is timely because it will provide information to almond and other tree crop producers to address AB32 GHG reduction targets in 2020 for agriculture. Development of tools and protocols must be fast-tracked and parallel with basic field research. The proposed project builds on existing research projects by expanding the scope of field research in regions of high importance to the California specialty crop industry and that are currently under represented in the programs established by the Almond Board of California, California Air Resources Board and the California Energy Commission.

Funding Resources

This project is funded by resources from the following organizations and programs:

Almond Board of California
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USDA/CDFA
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