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

Environmental Stewardship/Crop Protection – Project No: 10-STEWCROP4

Background & Purpose

There is widespread interest in better understanding and quantifying the carbon (C) balance of different pruning strategies as California faces potential cap and trade regulations of greenhouse gas (GHG) emissions as well as legislation focused on burning activities. This project explores the influence on soil C and reduced emissions as a result of applying chipped prunings to the orchard floor as an alternative to burning. The work will also summarize management efforts and the successes and challenges of chip application. The recent industry trend of shifting away from the traditional method of burning annual prunings in favor of chipping and leaving them to decompose on the orchard floor could mean increasing organic matter stored in orchard soils, enhanced soil moisture holding capacity, improved air quality, etc. Burning has become problematic owing chiefly to the implementation of more stringent air-quality regulations. Although new, this project builds on previous work that has focused on the influence 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 impact soil carbon stocks and air quality. Employing a statewide approach, the project will take into account the significant regional and sub-regional differences among orchards in terms of soil types, irrigation methods, between-row vegetative covers, and orchard-management practices. These rank as the key factors that influence carbon dynamics of applied prunings and the effective management of the process. Given the statewide scale of annual prunings disposal (about 400,000 tons), this project is likely to not only enhance the state's production of almonds, but also have practical application for other kinds of annually pruned tree crops. Enhanced prunings management has far reaching impact on valley-wide improvement to air quality, addresses ever-increasing regulatory pressures on growers, reduces GHG emissions, increases soil carbon/organic matter reserves, optimizes between-row vegetation management, and also improves soil/moisture relationships directly applicable to this specialty crop.

Objectives

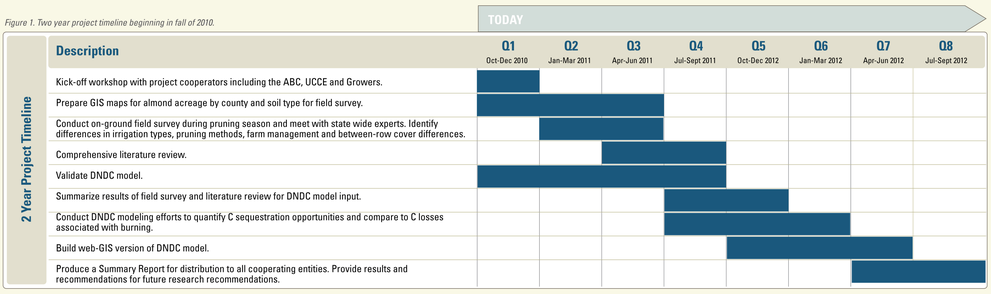
Project objectives are designed to encompass actual field practices, available literature, ongoing research and the latest in modeling efforts to:

- Review almond field pruning and chipping practices statewide
- Summarize existing research on pruning management impacts of soil carbon and net GHG emissions
- Provide input parameters to the DeNitrification/DeComposition (DNDC) GHG soil biogeochemical model
- Build GIS and remotely sensed databases of soils, climate and orchard management, orchard location, irrigation systems, etc.
- Ascertain carbon 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 carbon 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

This project is currently in the beginning stages of development and will be conducted over the next 2 years, ending in the fall of 2012 (Figure 1).

Figure 1. Two year project timeline beginning in fall of 2010.



Approach

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

Field Review

To be conducted during the pruning season of 2010 and 2011. Will encompass a 2 to 3 week review of varying management practices across a variety of growing regions. Will include interviews with growers, extension specialists and industry professionals and experts.

Literature & Research Review

All pertinent literature and on-going research will be reviewed and summarized for the purposes of supporting the field review as well as directing the development of input parameters for the DNDC model.

GIS Development

A GIS in conjunction with some remotely sensed information will be developed specifically for statewide almond production. It will include variables such as planting locations, soil type, climatic regimes, regional and sub-regional management practices, planting densities, etc.

DNDC Modeling

A significant portion of this project will include development of an almond-specific model that will be dependent on the results of the previous efforts, and will result in projections of improved C management.

Reporting

Will include comprehensive documentation, summaries and recommendations as a result of the entire project.

DeNitrification/DeComposition (DNDC) Model

DNDC stands for Denitrification and Decomposition, two processes dominating losses of N and C from soil into the atmosphere (Figure 2). The development and validation of the DNDC model has been extensive, applied to cropping systems throughout the world and is a leading resource for estimation of C and N management in cropping systems. 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 California 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 (Figure 3)
- 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, tomatoes and walnuts

DNDC validation and efforts specific to California crops includes 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 effort will create an important validation dataset for almonds, specifically for woody vegetation (Figure 4). 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 w/ surface application and chipping with incorporation)
- Compilation of differences in soil organic carbon storage according to previously developed approaches (Figure 5) and GHG emissions due to burning versus chipping/orchard floor application over the short and long-term

Figure 2. Input, processes and output components of the DNDC model for bridging ecological drivers and GHG emissions

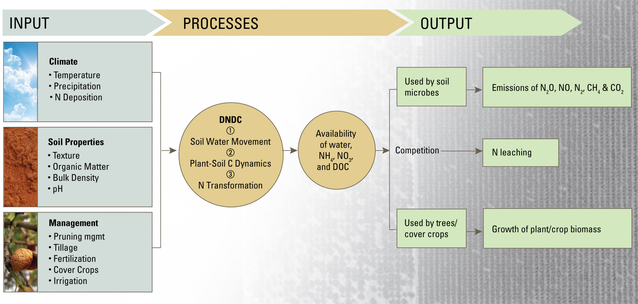


Figure 3. Examples of extensive historic and current model validation

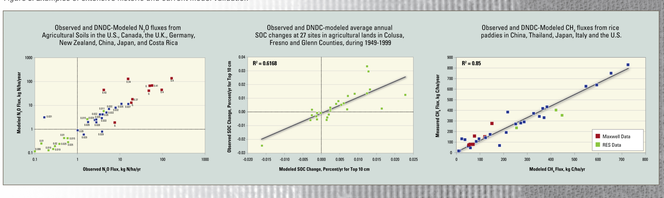


Figure 4. Example DNDC flow diagram for C management of woody vegetation and prunings

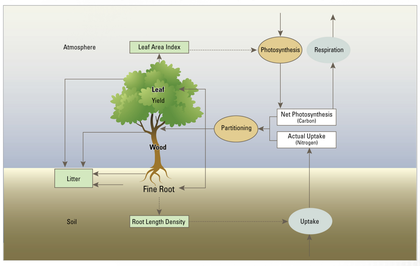
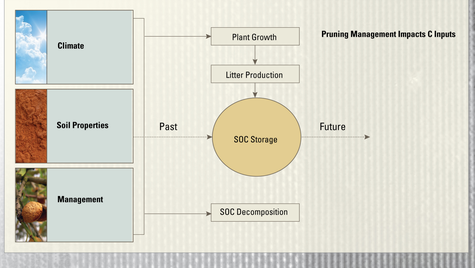


Figure 5. Soil organic carbon dynamics as influenced by the balance of soil C-input and output



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. It should be noted that 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 carbon 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 potential GHG reduction targets for agriculture. Development of tools and protocols must be fast-tracked and in 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
EnvironmentalStewardship/Crop Protection

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