A Life Cycle Assessment of Greenhouse Gas Emissions for Almond Production in California

Lead Investigator — Alissa Kendall, PhD[1]; Co-Investigator — Sonja Brodt, PhD[2]; Graduate Student Researcher — Elias Marvinney[3]

1. Dept. of Civil and Environmental Engineering, amkendall@ucdavis.edu; 2. Agricultural Sustainability Institute, sbbrodt@ucdavis.edu; 3. International Agricultural Development

Motivations for this Research:

- Growing interest from consumers and governments for 'carbon accounting' in Europe and the U.S.
- Reducing greenhouse gas (GHG) emissions can save growers money and reduce dependence on foreign oil because GHG emissions are linked to fuel and fertilizer use.
- We need to conduct a California-specific assessment instead of relying solely on global calculations of climate footprints of food products, because GHG emissions vary according to climate, soil, transport distance, and other geographically sensitive variables.

Research Objectives

- Track all inputs and outputs (see below for more detail) for a "typical" California almond orchard
- Quantify upstream inputs and impacts associated with each input to almond production (e.g. the inputs required to produce fertilizers and fuels)
- Quantify total energy use, emissions of greenhouse gases, and other pollutants per lb or kg of almonds
- Create a modeling tool that will identify the "hot spots" for greenhouse gas emissions and energy use in a typical California almond production system. This tool can help to answer questions such as these below:

How much do off-farm inputs contribute to an orchard's GHG footprint, compared to on-farm operations?

To reduce the GHG footprint, is it more important to reduce tractor passes or to reduce prunings?

How will changing from flood to micro-sprinkler irrigation affect an orchard's GHG footprint?

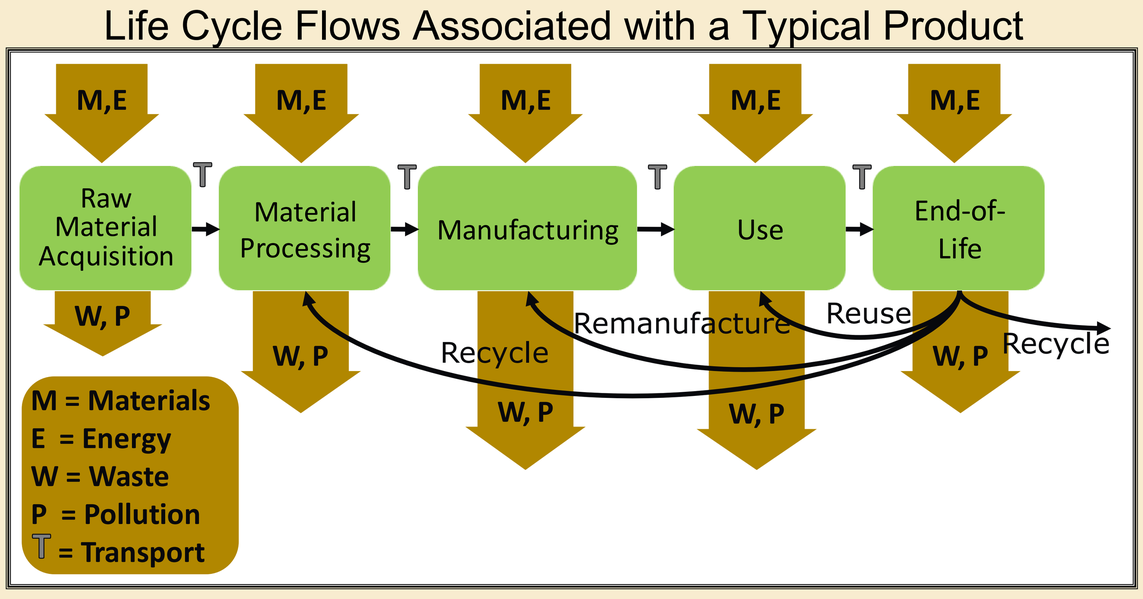
1. Life cycle assessment

Life Cycle Assessment tracks the energy and material inputs, and waste, pollution, and product outputs over a system or product's life cycle.

These input and output flows are then translated into environmental impacts. For example, greenhouse gases (CO_2, N_2O and CH_4) are converted into global warming potential to reflect their potential impact as greenhouse gases.

By tracking these flows, life cycle assessment systematically accounts for the resource flows and environmental impacts associated with a process or product. This allows for a scientifically robust and quantitative approach to evaluating the environmental sustainability of a product or process

Life Cycle Flows Associated with a Typical Product



2. Life cycle flows in almond production

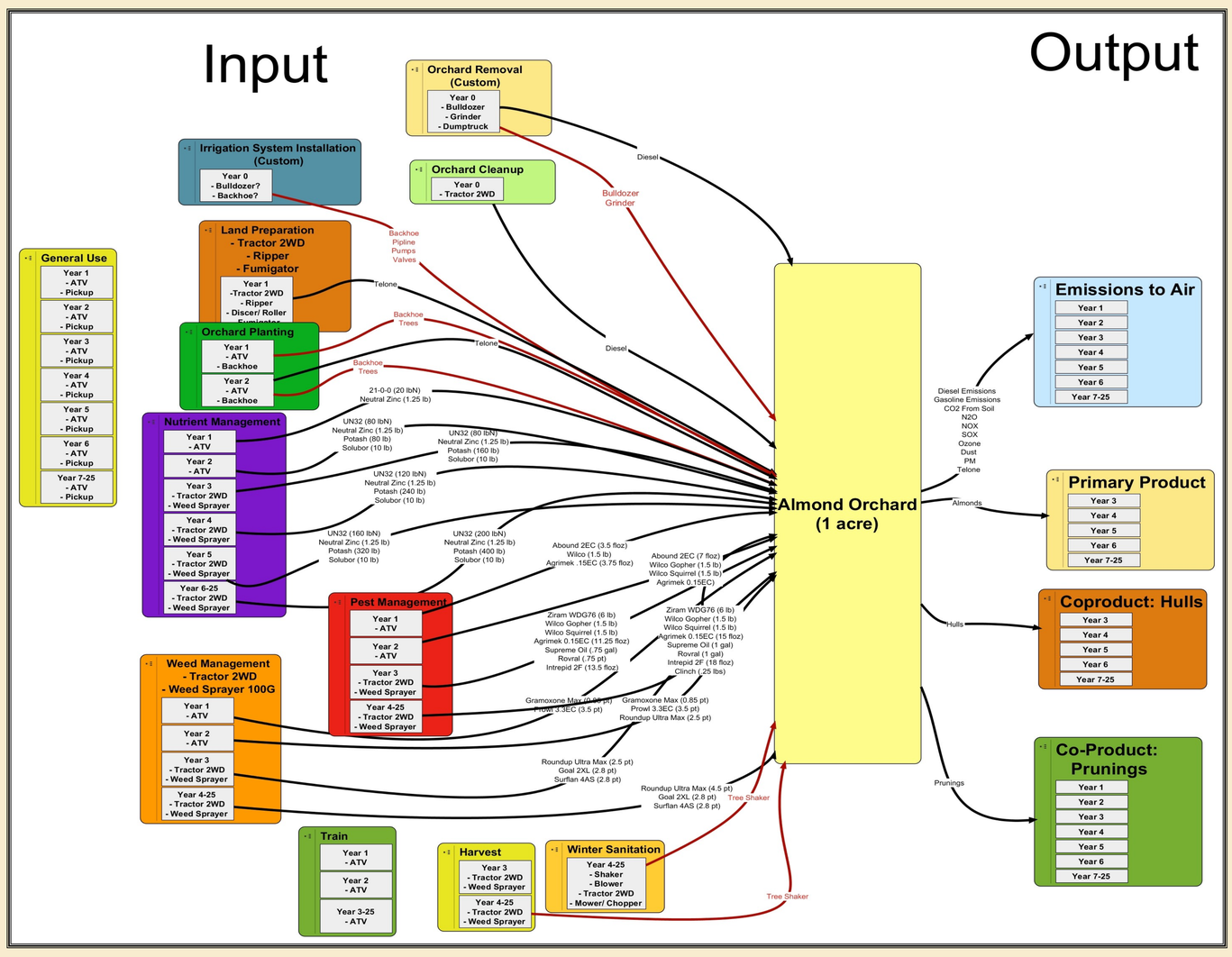
In an energy or carbon footprint we apply life cycle assessment principles to energy use and greenhouse gases

Life Cycle Energy and Greenhouse Gases for Almonds

INPUTS
Diesel fuel, fertilizer, equipment, pesticides, nursery operations, etc.

Orchard Removal & Establishment: Tree removal, land prep, planting, etc. → Orchard Maintenance: Pruning, irrigation, fertilization, pest management, tree replacement, etc. → Harvest: Equipment operation, post-harvest management → Farm Gate

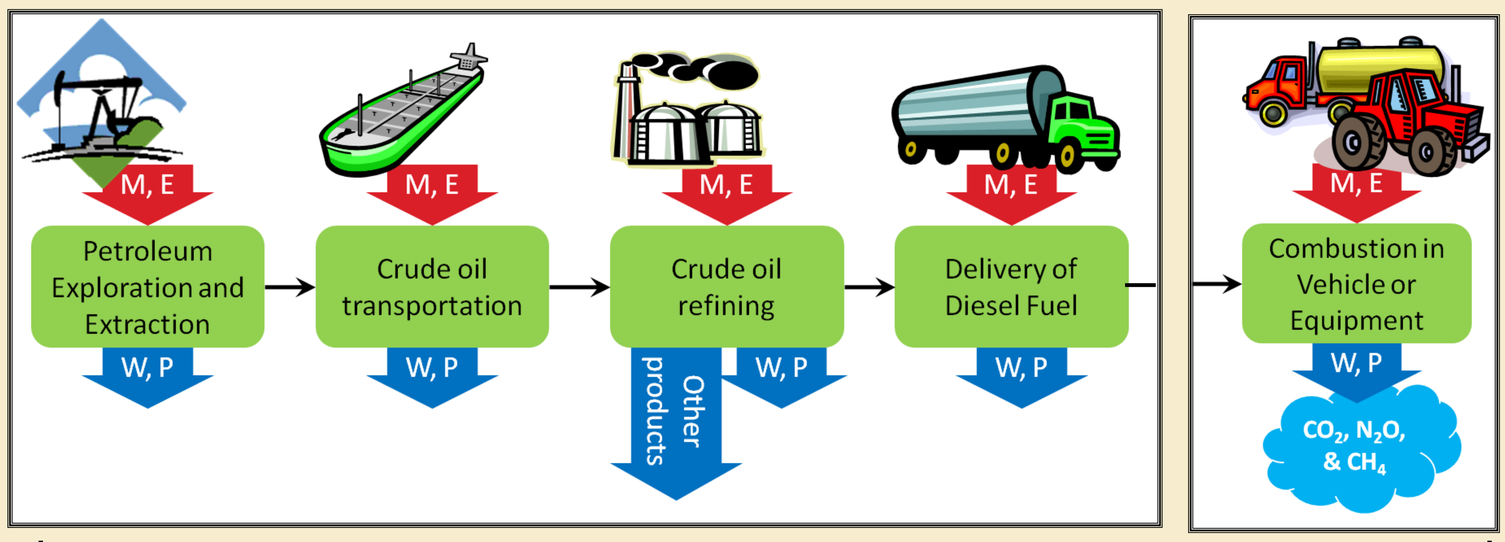
OUTPUTS
Carbon Dioxide, Nitrous Oxide, Methane, Co-products (hulls, woody biomass)



2. Preliminary Results: Life cycle energy and greenhouse gas emissions for grower fuel use

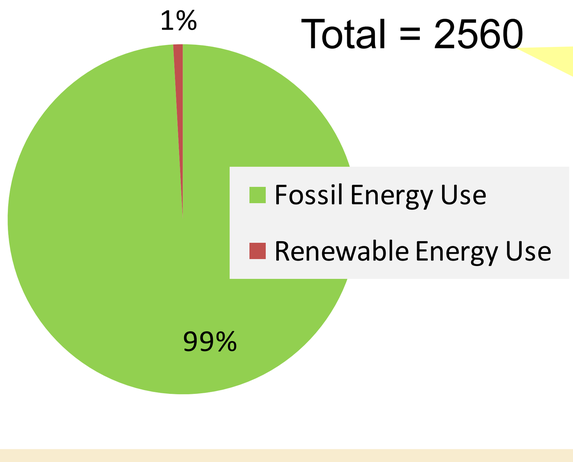
Preliminary results are presented ONLY for fuel use by growers. Any fuel use by custom operators is excluded. This means that custom operations' agrochemical production, irrigation, and field emissions are not presented in these results.

Diesel Life Cycle Pre-Combustion | **Diesel Life Cycle Combustion**



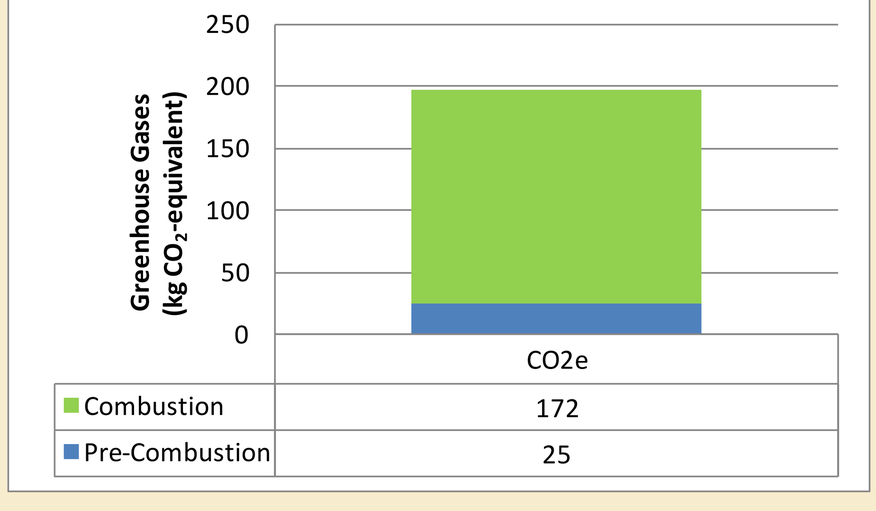
This is equal to emissions generated by using 320 kWh of electricity

Primary Energy Use per Acre (MJ)



This is equal to about 17.5 gallons of diesel, or 40% of a barrel of oil

Greenhouse Gas Emissions from On-Farm Diesel Use per Acre of Almonds



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