Monitoring WOR impacts on soil and air quality

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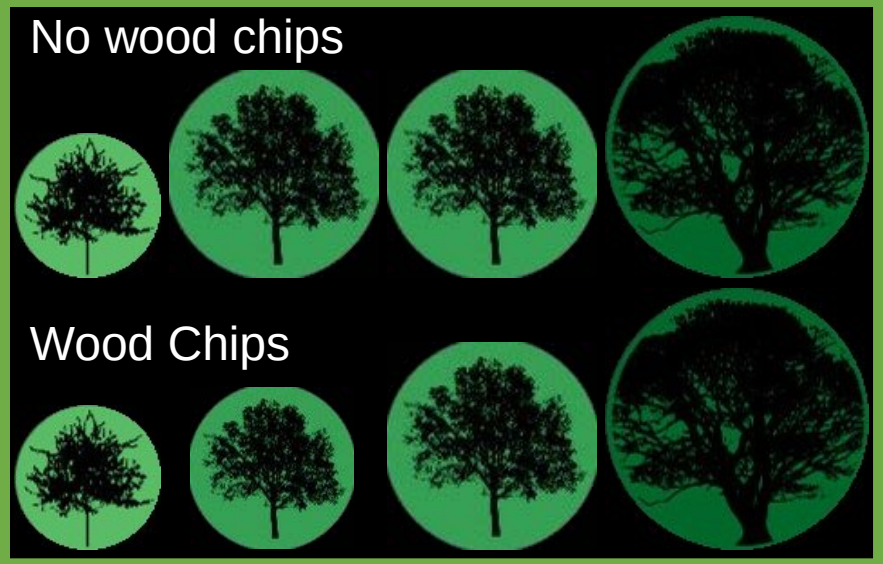
Whole Orchard Recycling

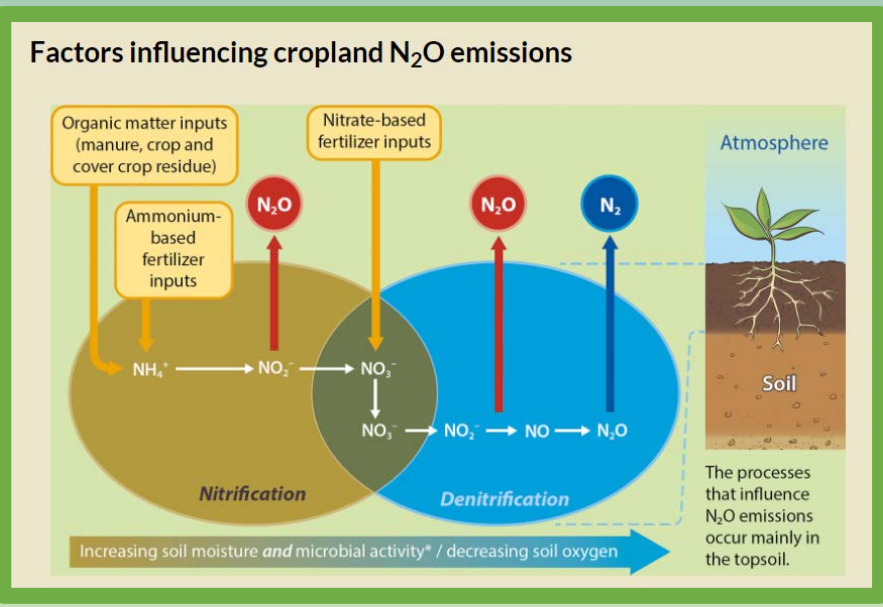
- WOR is the grinding and returning of whole trees to the soil at the end of an orchard's life.
- Orchard trees store carbon in woody biomass over decadal time scales. This C storage leads to a net 14-18% reduction in CO_2-equivalent emissions (Marvinney et al., 2015).
- WOR is an alternative to burning or sending wood to cogeneration plants that are facing closures.
- WOR presents an opportunity for long-term storage of C in the soil and overall improvement of soil physical and biological properties.

Potential Benefits of WOR

- Improved soil “health” due to:
  - Increased soil organic matter
  - Increased soil moisture & water retention
  - Increased nutrient retention
  - Decreased soil compaction / bulk density
  - Higher microbial diversity
- Enhanced soil “health” may lead to greater tree resource use efficiency (i.e., water & nutrients).
- Ultimately, orchards may have greater resilience to irrigation water shortages and healthier trees.

WOR Concerns





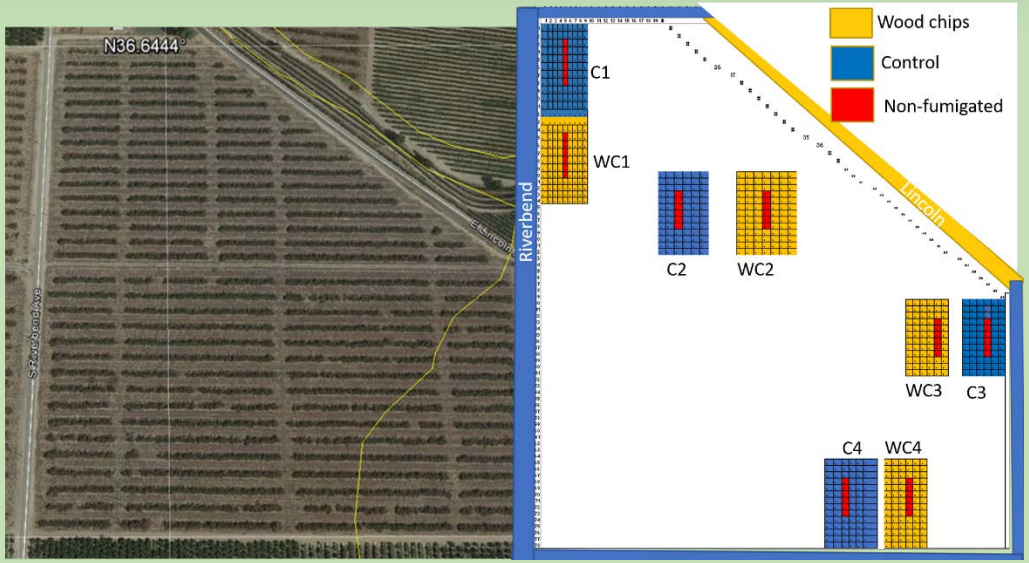
- WOR increases soil carbon-to-nitrogen ratios.
- High soil C:N reduces N availability and may negatively impact early tree growth & nutrition.
- N fertilization can lower soil C:N.
- However, applying N fertilizer may increase emission of greenhouse gases such as nitrous oxide (N_2O) and other NOx gases.
- N fertilization may also result in more leaching of nitrate (NO_3^-) into groundwater.

Research Questions

- What are the short- and long-term impacts of WOR on soil physical and chemical attributes?
- What are the effects of WOR on soil processes, such as N_2O and CO_2 emissions, N mineralization, denitrification, nitrification, etc.?
- How does WOR influence soil microbial communities?
- What are the impacts of WOR on tree growth, nutritional status, water use efficiency, nitrogen use efficiency, yield, etc.?

Field Trials and Measurements

Field Trial Location	Date
Riverbend/Lincoln Ave, Parlier, CA	**2018**
CSU Fresno	**2017**
Wonderful Orchards, Kern County	2016
Manteca, San Joaquin County	2015
Kearney Research Station	2015
Chowchilla, Madera County	2015
Kearney Research Station	2008



Soil physical and chemical attributes:

- pH, bulk density, electrical conductivity, moisture
- Inorganic (NO_3^- & NH_4^+), dissolved organic, & total N
- Dissolved organic C (including labile pool), total C
- Micronutrients: N, P, K, Ca, Mg, Na, Mn, Zn, Fe, Cu
- Organic matter, soil aggregation

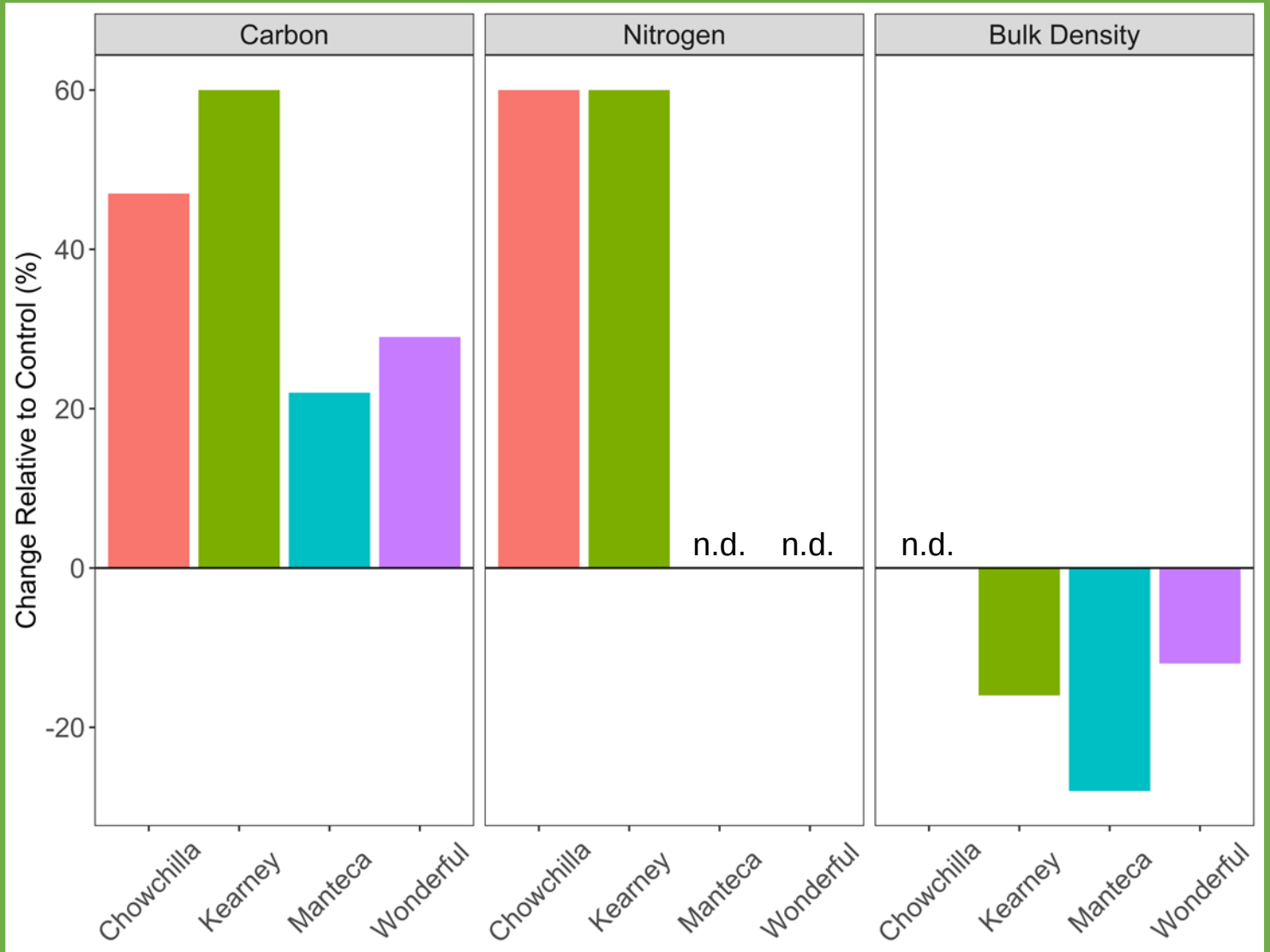
Soil processes

- N_2O and CO_2 fluxes and N mineralization
- Soil microbial community profiling

Tree responses

- Leaf tissue analyses, trunk cross sectional area, yield
- Stem water potential, stomatal conductance
- Effects of pathogens

WOR Impacts on Soil C, N, Bulk Density

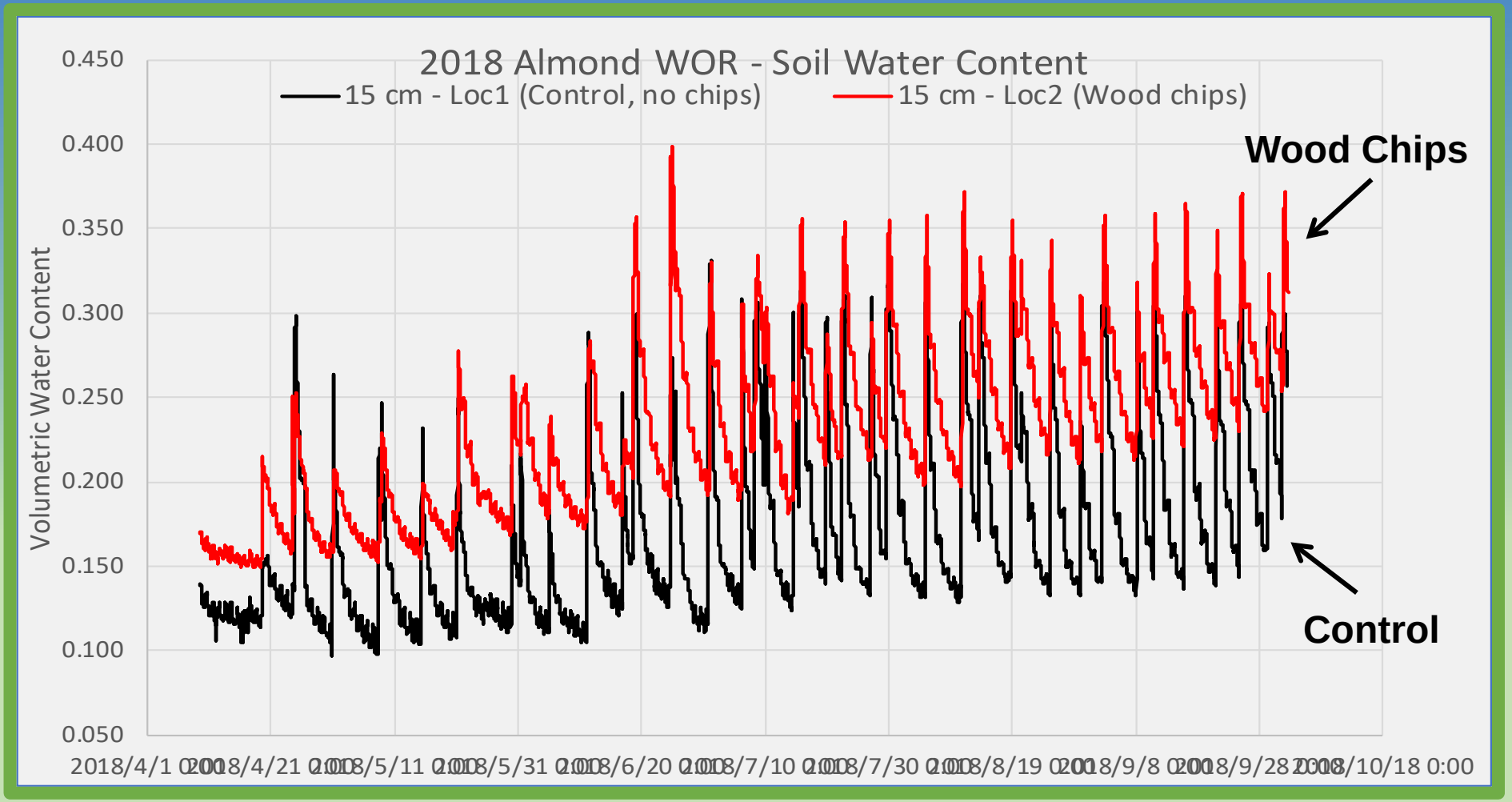


Field Trials established in 2015 and 2016

- Increases in soil C and N
- Decrease in bulk density, indicating less soil compaction

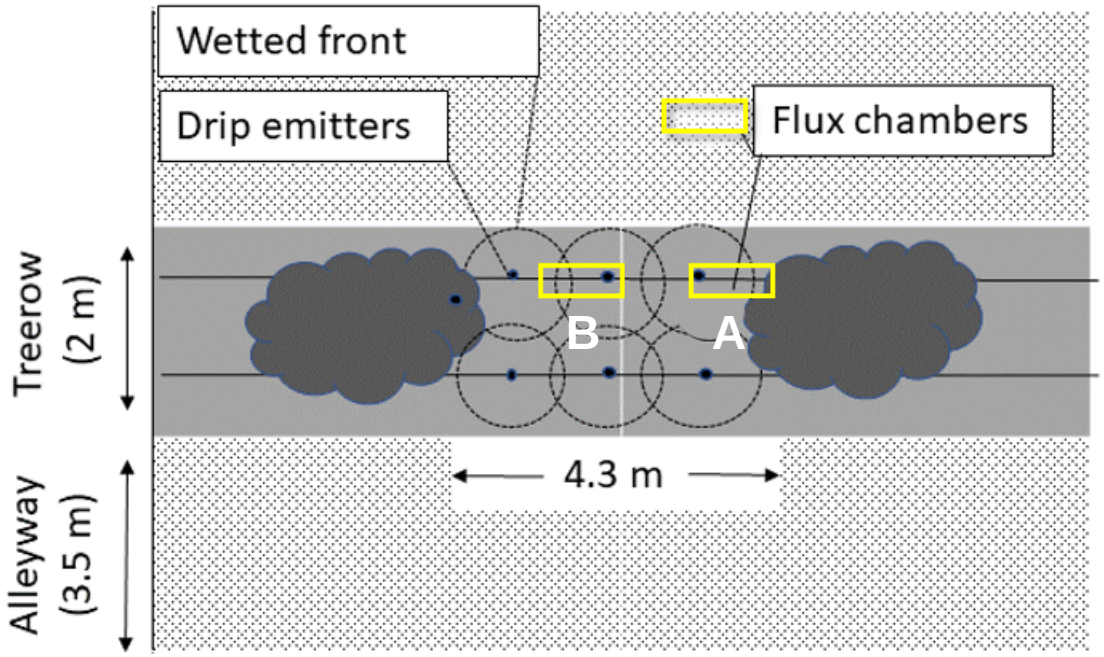
Data from A. Gaudin and E. Jahanzad

WOR Increases Soil Moisture



Riverbend and Lincoln Ave, Parlier, CA Trial

Measuring Soil N_2O and CO_2 Fluxes



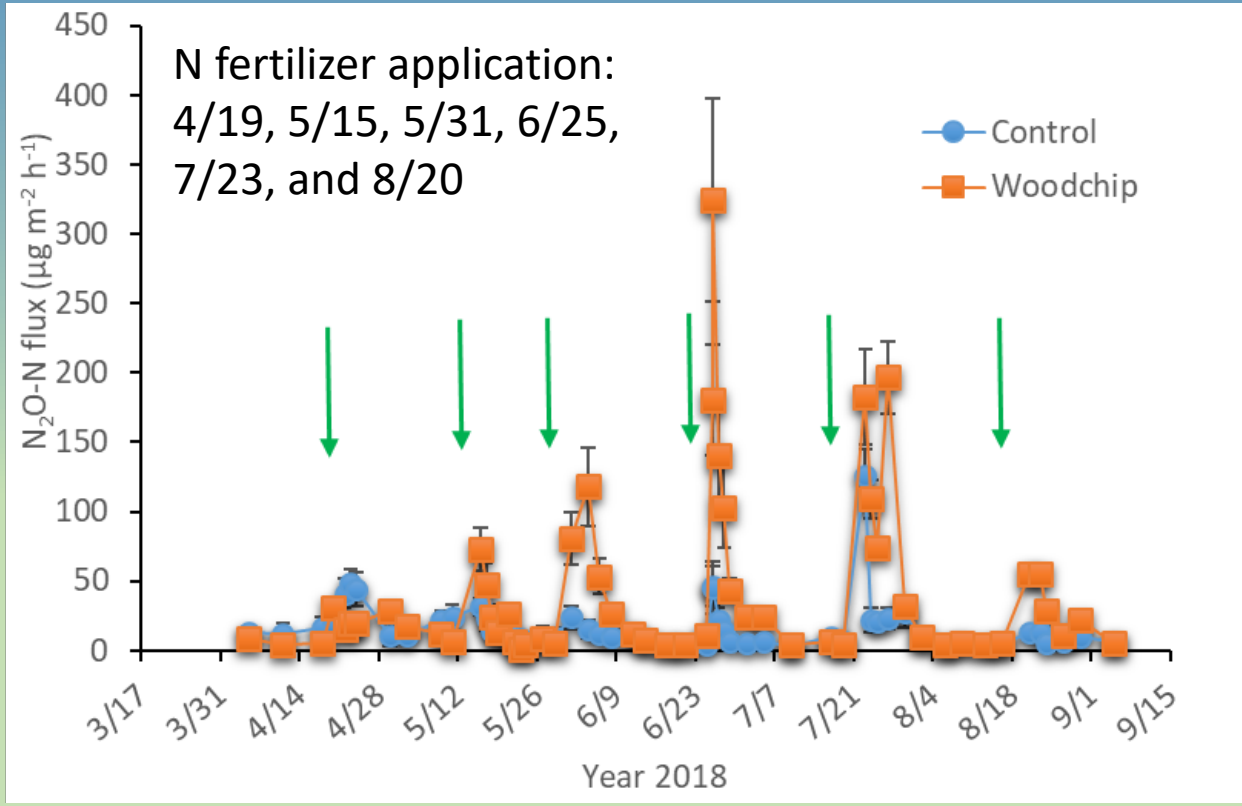
Riverbend and Lincoln Ave, Parlier, CA Trial

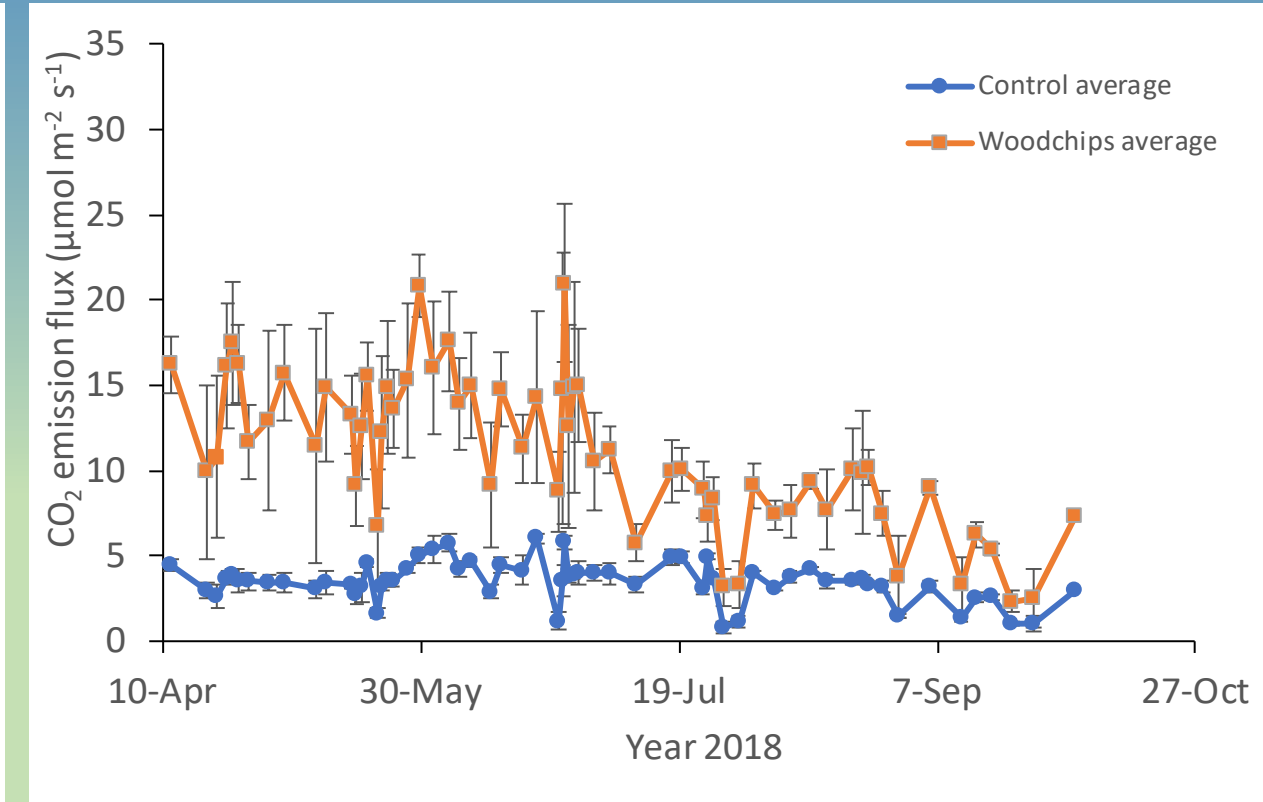
- 4 control plots and 4 wood chip plots with 2 flux chambers per plot
- Year-round measurements in tree drip zone (A) and tree row middle (B)
- N_2O accumulation in chamber is measured over time (< 1 h)
- CO_2 is measured via an automated soil gas flux system

WOR Effects on N_2O and CO_2 Fluxes

N_2O fluxes peak 1-2 days after fertilization

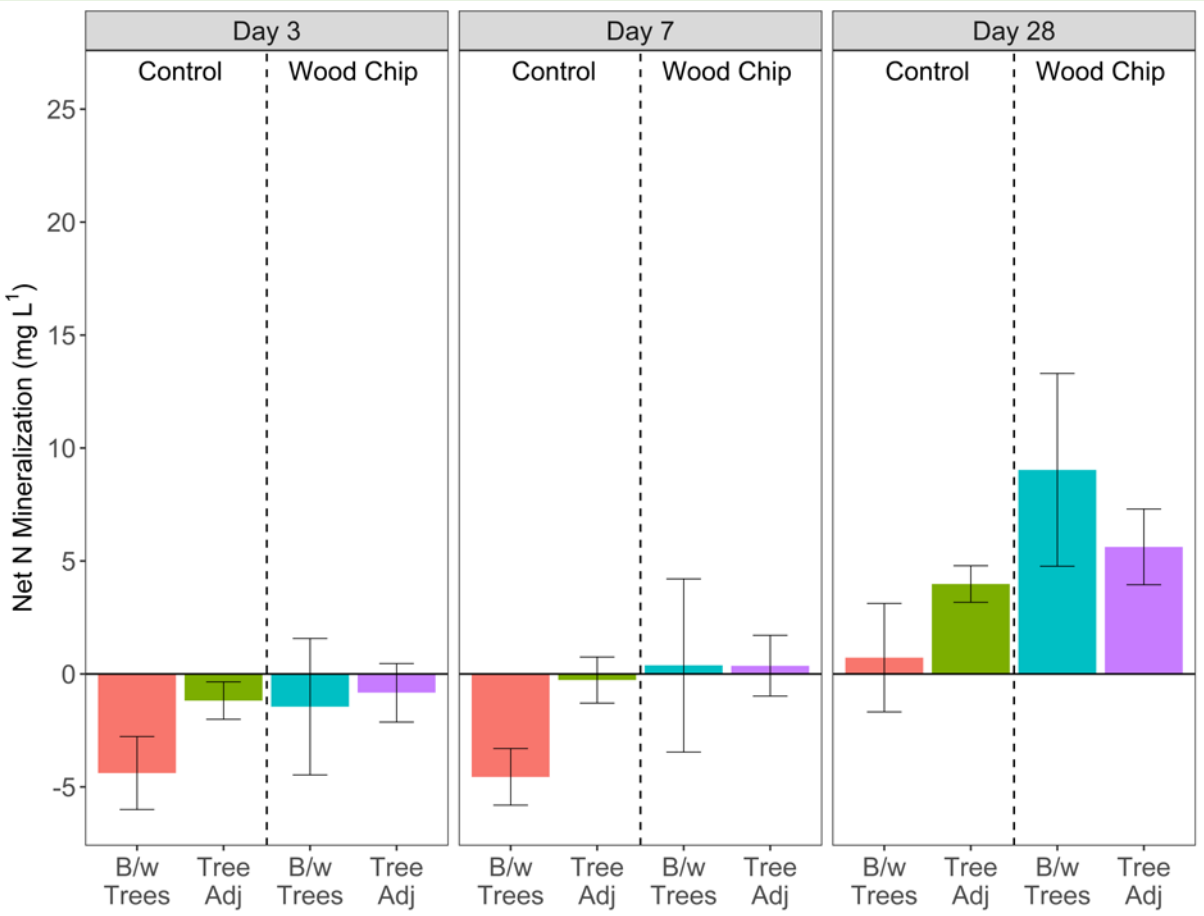
CO_2 emissions are higher in wood chip soil

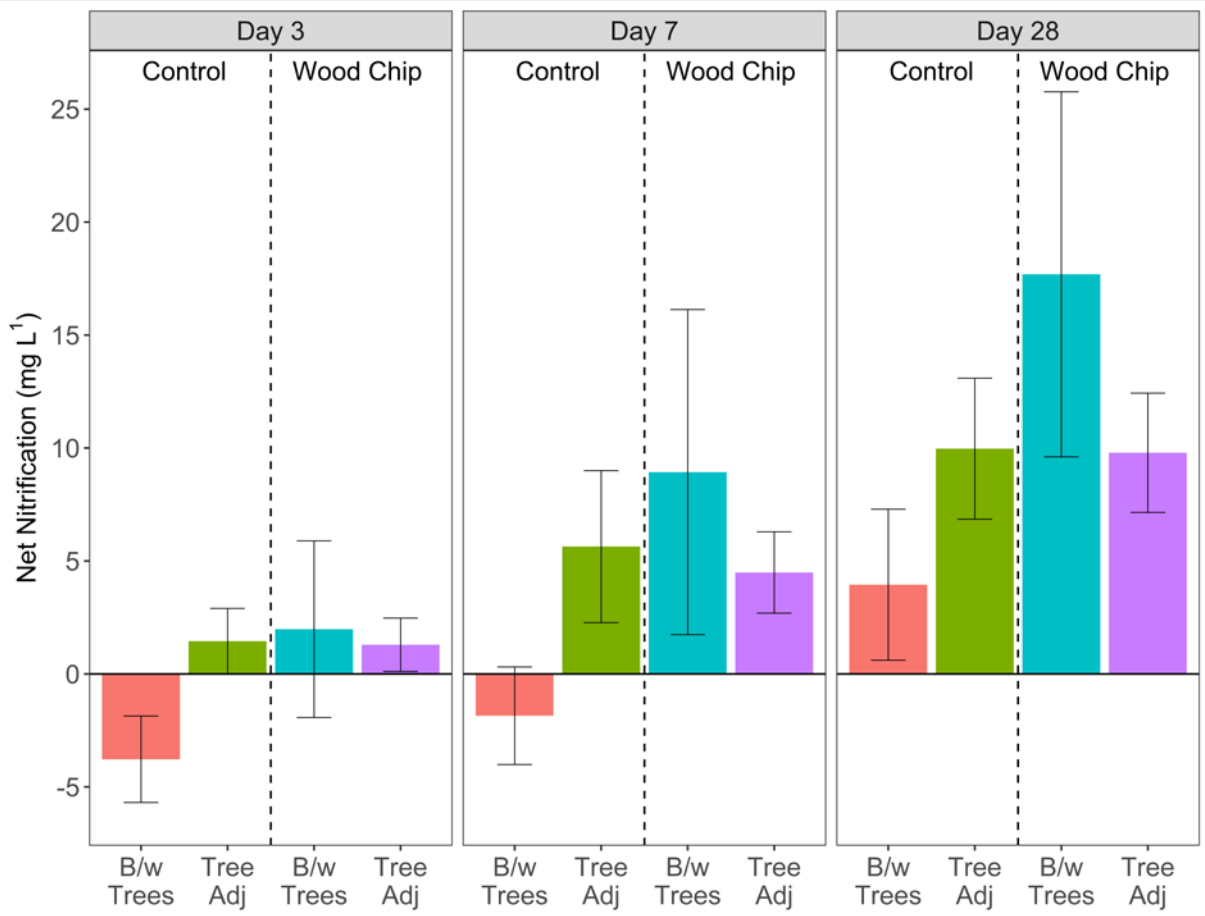




- Averaged the A (tree drip zone) and B (tree row middle) measurements

N immobilization in WOR soil?





Net N mineralization

$(NH_4^+\text{-}N + NO_3^-\text{-}N)_{t+1} - (NH_4^+\text{-}N + NO_3^-\text{-}N)_t$

Negative values indicate immobilization

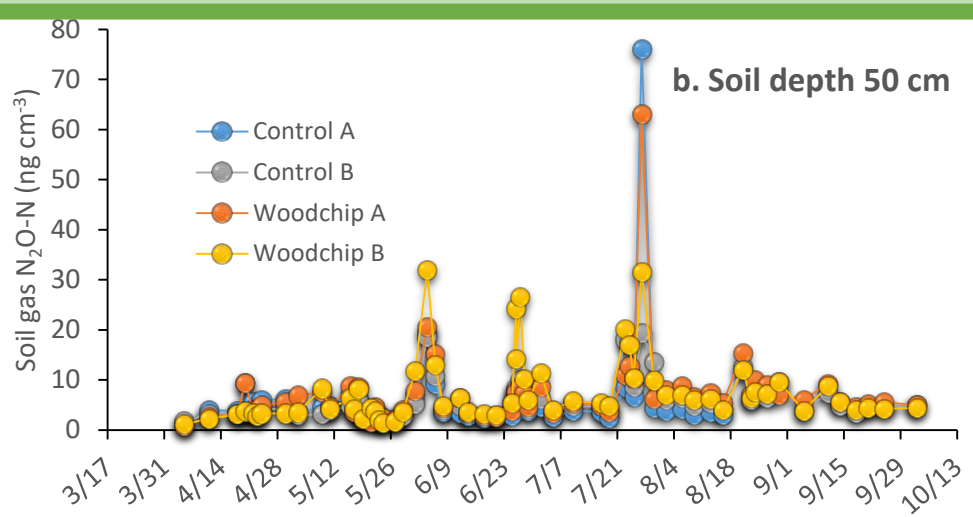
Net nitrification

$(NO_3^-\text{-}N)_{t+1} - (NO_3^-\text{-}N)_t$

Inter-Tree Space Nitrate Leaching

Riverbend and Lincoln Ave, Parlier, CA Trial

- Soil N_2O response at depth suggests movement of N below root zone
- Quantifying differences in N losses between wood chip and control plots where tree roots will not access applied fertilizers
- Buried bags with resin to capture nitrate over course of season



Summary

- What are the short- and long-term impacts of WOR on soil physical and chemical attributes?
  - WOR tends to increase soil C, N, and moisture and decrease soil compaction over a ~2 to 3 year time period
  - Kearney 2008 WOR trial (wood chip versus burning) shows wood chips increase soil organic matter and soil aggregation (Gaudin & Jahanzad)
- What are the effects of WOR on soil processes, such as N_2O and CO_2 emissions, N mineralization, denitrification, nitrification, etc.?
  - Initial data suggests peak N_2O fluxes may be higher in wood chips (but still much less than other cropping systems) and CO_2 emissions are higher with wood chips
  - Nitrification may play an important role both the wood chip and control soils
  - Additional data is needed to establish patterns and examine nitrate leaching
- Data collection and analyses on microbial communities and tree responses is ongoing