Sustainability at Russell Ranch – Carbon Footprint Analysis

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Identified Problem

The UC Davis Agricultural Sustainability Institute (ASI) operates the 300-acre Russell Sustainable Agriculture Facility in West Davis, California. Researchers at Russell Ranch have measured the long-term impacts of crop rotation, farming systems, and inputs of water, nitrogen, carbon, and other elements on agricultural sustainability for over 23 years. Russell Ranch is home to 72 one-acre plots, a quarter-acre barn, an air-conditioned sample storage facility, dedicated irrigation plots, and other larger plots for scale-up research. The ranch operates a variety of agricultural machines that run on electricity and fossil fuels including, two well pumps, two air-conditioned portable buildings, several tractors, trucks, ATVs, and various machine shop equipment.

Project Description

Russell Ranch has an ongoing mission to increase the sustainability of its operations and serve as a demonstration farming facility. While numerous studies of specific farming practices have taken place on the farm, prior research has not endeavored to develop a holistic understanding of the farm's total greenhouse gas emissions. To address this gap in the existing literature, our team partnered with Russell Ranch's Director Dr. Kate Scow and Facility Manager Israel Herrera to collect data and create a tool capable of calculating the farm's carbon footprint. As part of this project, we agreed to provide the following deliverables:

1. Compile data about emissions sources on the ranch,
2. Provide a carbon footprint analysis of the baseline condition,
3. Identify relevant opportunities to reduce energy use and emissions,
4. Analyze the feasibility of each recommendation.

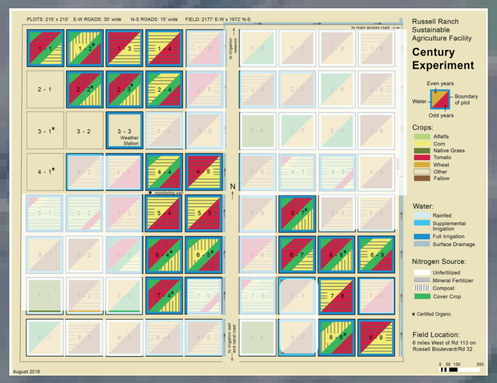


Figure 1: 72
One-acre plots at Russell Ranch, broken down by crop type, irrigation method, and nitrogen source. The heighlighted part is this project's crop's focus and the shaded was not included in the study

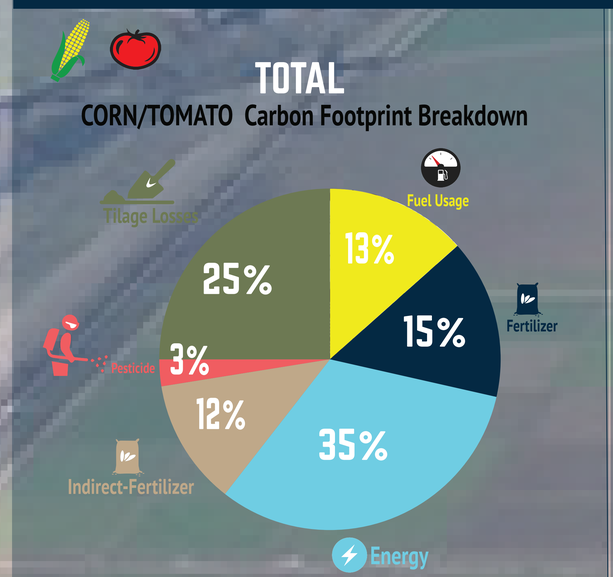
Methodology

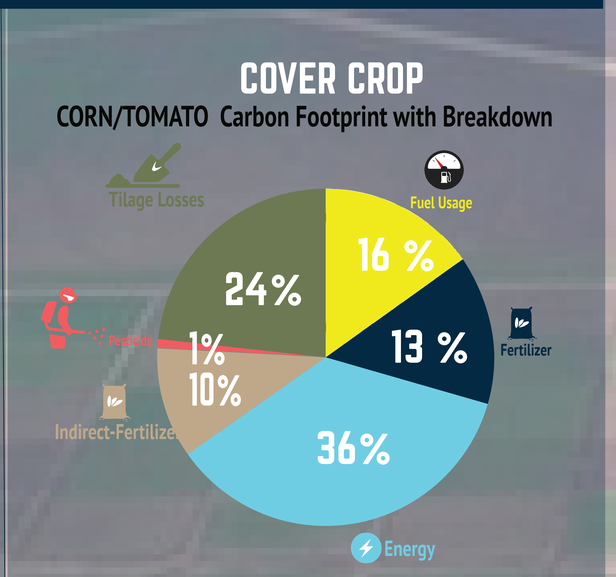
To analyze the conventional tomato/corn rotation against the mixed corn/tomato/-cover crop rotations we broke down the emissions into two categories.

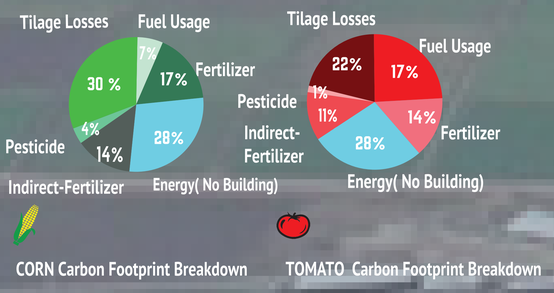
Direct Emissions:
Fuel usage of farm operations
Direct emissions of fertilizer application Electricity use in buildings and pumping

Indirect Emissions:
Production, packing, storage, and distribution of fertilizers and pesticides Nitrogen Volatilization (Fertilizer) Leeching/Run-off (Fertilizer)
Tillage Losses
Carbon Sequestration

Results

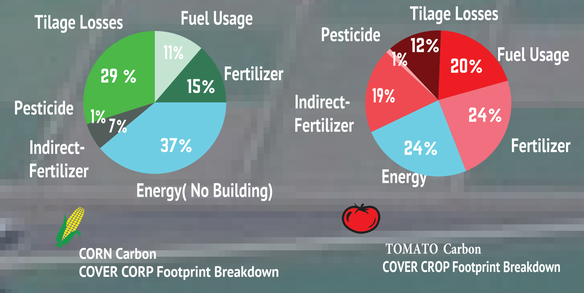






CORN Carbon Footprint Breakdown

TOMATO Carbon Footprint Breakdown



CORN Carbon
COVER CORP Footprint Breakdown

TOMATO Carbon
COVER CROP Footprint Breakdown

Uncertainties & Next-Steps:

There were a number of uncertainties in the data which can be further improved to provide a more accurate fooprint

Area of Interest	Uncertainty	Next Steps
Fuel	No direct fuel usage & missing fuel usage for non-farm operational vehicles. The fuel usage was estimated from a cost-analysis breakdown of the fields	Gather direct data for fuel usage for both farm operations and non-farm operations
Pesticides	Not enough time to breakdown pesticide constituents and their effects	Perform a study and analysis on the pesticide usage and their emissions
Energy	Scale of data too broad to narrow down per field properly	Perform analysis on the cost of pumping groundwater
Tillage Loss	Relied solely on an online tool, Cometfarm.net	Perform multiple studies on soil properties, the effects of tillage on the ranch and the flux rates of greenhouse gasses. This area has the most room for improvement, but is also the most complicated.
Fertilizer	Indirect emissions could be better analyzed	Gather necessary data to use Intergovernmental panel on climate change (IPCC) equations to their full extent
Carbon Sequestration	No data received	Gather the data from systems/reports and bring it into the footprint.

Carbon Foot Reduction

Carbon Footprint Reduction Strategies

Based on the plots we studied, it appears that activities to reduce the consumption and carbon intensity of electricity, fertilizer, and diesel would have the greatest impact on Russell Ranch's carbon footprint.

1. Increase Use of Cover Crops
2. Use Digestate from UC Digester to Replace Synthetic Fertilizer
3. Use Compost from On-campus Compost Bins .
4. Use Biodiesel Blend to Fuel Tractors
5. Rainwater Catchment

Evaluative Matrix to rank the best reduction strategies

Evaluation Criteria	Weights
Cost (upfront capital and total NPV)	3
Fundable (available grants, etc)	2
Transferable / Scalable	2
GHG Impact (% of footprint reduction)	3
Demonstrable	1
Potential for collaboration with other units on UC Davis	3
Compatibility with current/planned research and overall mission	1

Conclusion

Breaking down Russell Ranch's complex carbon footprint involves a lot of different data sources and information. Our preliminary tool and results show that energy through pumping, fertilizer use, and tillage losses are the three most significant sources of carbon. Fuel usage was semi-significant, but is worth addressing due to the ease of managing it in comparison to the other sources. Tillage losses is the most complex category and will take the most work/resources in order to un-derstand. Overall our tool will be useful for Russell Ranch to receive a preliminary understanding of their carbon footprint and steps to try and reduce it in the future.

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