Soil Health Demonstration Trials: Conquering Cover Crop Challenges Coast to Coast

Technical Note

Purpose

This document details the methods used to collect and analyze soil, plant, and economic data associated with the Cover Crop Demonstration Trial Case Studies, which describe seven farmers' participation in a five-year on-farm cover crop demonstration trial network. The case studies are available here: https://farmlandinfo.org/publications/cover-crop-demonstration-trial-case-studies/

American Farmland Trust's national-level on-farm demonstration trial enabled the collection and analysis of soil, economic, and social data provided by participating farmers who agreed to implement a new cover crop-related soil health practice that addressed a regional barrier to practice adoption. An in-depth description of the project is available here: https://farmland.org/conquering-cover-crop-challenges. The 15 trial farms implemented one or two soil health management practices to compare to their business-as-usual practices. Soil health and economic data were collected annually.

Soil Health and Plant Productivity Analysis

1. **Soil Sampling**

To determine the effects of the treatments on soil health, soil samples were collected annually from each farm in the spring (unless otherwise indicated in the case study) for quantitative laboratory assessment, and soil health was assessed in-field via a qualitative assessment at the same time.

For soil samples in replicated plot designs, one main location was identified per plot. For comparison or split fields without replication, three main locations were chosen randomly per field or field area. At each location, five 2 cm x 15 cm soil samples were collected using a drain spade, generally following the approach described in Moebius-Clune et al. (2016, p.27), one from the main location and 4 from within 20 ft of the main location. The five soil cores were combined and homogenized to form a single composite sample. From that composite, 1 L of soil per plot was sent to the Cornell Soil Health Lab for the Comprehensive Assessment of Soil Health (CASH) to assess specific soil health indicators.

For the qualitative analysis, one main location was randomly chosen per treatment per year for the NRCS in-field soil health assessment.

2. **Qualitative NRCS in-field soil health assessment**

The **NRCS in-field soil health assessment** qualitatively analyzes the top 12 inches of the soil profile, evaluating whether 11 indicators meet threshold criteria. Resource concerns (compaction, soil organism habitat loss, organic matter depletion, and/or aggregate instability) are identified if certain combinations of indicators do not meet assessment criteria. This qualitative assessment can identify areas of concern for potential improvement through management and is used by NRCS conservation planners in the evaluation of resource concerns and development of conservation plans. To learn more, please refer to the NRCS technical note 450-06 (USDA NRCS, 2020).

3. **Quantitative Cornell University Comprehensive Assessment of Soil Health**

The **CASH analysis** quantitatively assesses soil samples collected from the top six inches for particular physical, biological, and chemical soil properties, known as soil health indicators. The Cornell result interpretations compare samples to other farms of similar soil types that have been tested by the lab. Raw values are translated to scores based on soil texture and ranked from very low (worst) to very high (best). To learn more, please refer to the Cornell Comprehensive Assessment of Soil Health Manual (Moebius-Clune et al., 2016).

4. **Soil moisture and plant biomass**

For the NY farm, soil volumetric water content (VWC) and dry weight biomass was collected. VWC was measured in situ using a Campbell Scientific HydroSense II handheld sensor (Campbell Scientific). Measurements were taken to a depth of 0–20 cm at or near the time of cash crop planting. Two readings were collected between crop rows, avoiding the disturbed furrow. The cover crop biomass sampling was based on methods as described in Sullivan et al. (2020). The cover crop aboveground biomass was sampled in all three plots in the spring, both immediately before cover crop termination in the No Cover

Crop plots, and again one to three weeks later, immediately before cash crop planting. Cover crop biomass was collected from two sub-plot measurements in each plot within a 20.3 cm by 83.8 cm (0.17 m^2) metal quadrat, placed randomly in each sub-plot. Biomass samples were clipped using mechanical clippers, harvesting every plant just above the soil. The wet weight (g m^{-2}) was recorded in the field, accounting for the weight of the plastic bags. After obtaining the wet weight of each sample, one sub-sample was taken from each treatment. The subsample was sent to an analytical lab for determination of cover crop biomass dry weight.

5. **Data analysis**

All analyses were performed in R (v 4.3.2) (R Core Team, 2025) with RStudio (v 2025.5.1.513) (Posit Team, 2025). For replicated plot design trials, linear mixed-effects models, using the stat package (R Core Team, 2025), were used to evaluate the main effects of treatment and year, and their interaction for each individual soil health indicator in each farm. In all models, treatment and year were specified as fixed effects, and block was included as a random effect; $p < 0.05$ was considered significant. Marginal significance reflects $0.09>p>0.05$. In non-replicated trial designs, the linear models were run to assess potential significance, but the results were not reported as statistically significant.

Economic analysis

To provide the most accurate economic analysis for the farms represented in this study, national datasets were combined with farmer-provided operation data to calculate costs and ultimately determine net farm income.

1. **Farmer provided information**

Throughout the five years of the project, regular interviews were conducted to collect farming operation information data from each farmer. These data included the date of operation, the purpose of operation, the machinery used, the material used, the material cost, and any additional notes on why the operation occurred. Dates of operation were used to break out operations into individual cropping years, with the crop year starting after the cash crop harvest of the previous crop. If the rotation included double cropping, the crop year concluded after the second cash crop harvest. For example, a farmer with a corn-winter wheat-soybean rotation, crop year 1 would conclude after corn harvest, and year 2 would include both winter wheat and soybeans, concluding after soybean harvest.

Analyzing results in terms of crop year, rather than calendar year, allowed comparison of treatment effects on cash crops. This way, cover crop benefits would be attributed to the cash crop following the cover crop, resulting in a more accurate representation of actual farming operation mechanisms.

For each activity, the purpose of the operation was determined by the farmer with input from the interviewer. Purpose categories allowed for similar operations to be compared between treatments, and allowed for a finer analysis of individual operation changes from cover crop adoption. Purpose categories included cover crop planting, cover crop termination, tillage, cash crop planting, nutrient application, chemical application, harvest, irrigation, pruning, and mowing. Most categories matched across treatments for easy comparison; however, for control treatments without cover crops, some cover crop termination operations were also performed on the control treatment and would be categorized differently. For example, if a pre-plant herbicide was used on the cover crop treatment and categorized as "cover crop termination", the same herbicide operation on the control would be labeled as an "herbicide application". Labeling the operations in this manner allowed the study to produce a cover crop termination cost specifically for the cover crop treatments, while the herbicide application would come up in the net income calculation and offset the termination cost, resulting in no difference in net income. Using this method of categorizing operations allowed the study to produce cover crop-specific costs without misrepresenting the total cost impacts.

Farm machinery was heavily dependent on the individual farmer and their cropping system in the study. To produce accurate estimates for machinery costs, national machinery datasets (Table 1) were used as the per-acre machinery cost for each operation. That way the cost included the cost of equipment, labor, depreciation, interest, insurance, housing, repairs, and fuel. During the interviews, farmers identified whether they owned, rented, or custom-hired each operation. If owned or rented, machinery was matched either directly with the available machinery in the dataset or the next closest machine. To ensure accurate machinery matching, farmers provided machinery specifications for type, size, modifications, horsepower, make, and model for each machine. For operations that were custom hired, the costs of machinery were included in the farmer-provided cost amount.

Materials used and cost of materials as paid were provided by each farmer. This eliminated the risk of national datasets misrepresenting costs. One exception was for fertilizer material cost, where the farmer-provided price was cross-referenced with the national prices for N, P, & K to ensure consistency.

Cash crop yields were reported individually for each treatment by the farmer in terms of the common yield measurement for each crop, such as bushels per acre for grain corn or soybeans and tons per acre for silage. Treatment yields were multiplied by the national crop price for the specific cash crop to calculate each treatment's revenue, which was used in the partial budget analysis (section 3). Lastly, additional notes provided by the farmers were used to reference operations or provide a clearer picture for operation-specific items or pricing not common for all farms.

2. **National datasets used**

References for the national datasets can be found in Table 1. Operation data provided by the farmer were matched with national datasets information on machinery, crop input material, and crop pricing. These data were used to calculate the cost of each operation and the revenue from the cash crop. The national cost datasets produced citable, replicable operational costs, allowing for direct comparison by other farmers looking to incorporate cover crops.

3. **Partial budget analysis, cover crop costs, net incomes, and comparison**

The information from the national datasets and farmer-provided operation were analyzed using an Excel-based budget calculator. The calculator categorized all the information into the specific cost category and presented the crop year operation for each treatment as its own enterprise budget. In the enterprise and partial budgets, cover crop costs were calculated for establishment machinery, establishment material, termination machinery, and termination material. This allowed each treatment to have an estimate for adopting cover crops in the given system. Matching the enterprise budget categories, the Excel calculator then produced a partial budget to compare the differences between each treatment and the control. The partial budget analysis results were used to report differences in the various farms and treatments in the outputs for this study. A similar calculator can be found here: Retrospective Soil Health Economic Calculator.

Table 1: Economic Data Sources

Operational Costs	Source	Note/ Calculation if Applicable
Machinery Costs	Lattz, D. and G. Schnitkey. "Machinery Cost Estimates for 2021." farmdoc daily (11):143, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, October 12, 2021.	
	Iowa State University 2021 Iowa Farm Custom Rate Survey, March 2021	
	University of California Davis Department of Agriculture and Natural Resource Economics, 2019 Sample Costs to Establish an Orchard and Produce Almonds, San Joaquin Valley North	
	University of California Davis Department of Agriculture and Natural Resource Economics, 2019 Sample Costs to Establish an Orchard and Produce Almonds, San Joaquin Valley South	
	University of California Agriculture and Natural Resources Cooperative Extension Agricultural Issues Center, Sample Costs to Produce Processing Tomatoes, 2018; Custom Hire Cost	
	University of California Agriculture and Natural Resources Cooperative Extension Agricultural Issues Center, Sample Costs to Produce Processing Tomatoes, 2018	
	University of California Davis Department of Agriculture and Natural Resource Economics, 2016 Sample Costs to Establish an Orchard and Produce Almonds	
	University of California Agriculture and Natural Resources Cooperative Extension, 2020 Sample Costs to Establish a Vineyard and Produce Winegrapes, North Coast Region Napa County	
Labor Charge for Vineyard	University of California Agriculture and Natural Resources Cooperative Extension, 2020 Sample Costs to Establish a Vineyard and Produce Winegrapes, North Coast Region Napa County	1 ton/day/ picker @ 8 hr, $29.51/hr
Farm Labor Wage	BLS Occupational Employment and Wage Statistics, May 2023 data report. Hourly Mean wage for Agricultural workers, https://www.bls.gov/oes/2023/may/oes_nat.htm#45-0000	

Crop Prices		
Corn Silage	Hanchar, J. (2022, September). *Pricing corn silage – Fall 2022*. South Central NY Dairy & Field Crops Team. https://blogs.cornell.edu/scnydairyandfieldcrops/2022/09/01/pricing-corn-silage-fall-2022/#:~:text=Given%20recently%20available%20alfalfa%20hay,of%20about%20%2461%20per%20ton.	
Hay	USDA National Agricultural Statistics Service, Crop Values 2020 Summary, https://esmis.nal.usda.gov/sites/default/release-files/k35694332/348509606/d791t862r/cpvl0221.pdf	2020 US Average Price
Corn	USDA National Agricultural Statistics Service, Prices Received: Corn Prices Received by Month, US, https://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/pricecn.php	June 2021 Price
Soybean	U.S. Value – Price Paid to Farmers HistoryU.S. Value – Price Paid to Farmers History, SoyStats 2025	2021 Market Year Average
Wheat	Sowell, Andrew R., and Bryn Swearingen. Wheat Outlook: July 2022, WHS-22g, U.S. Department of Agriculture, Economic Research Service, July 14, 2022	
Almond	California Department of Food & Agriculture. (n.d.). California Agricultural Statistics Review. https://www.cdfa.ca.gov/Statistics/PDFs/2021_Ag_Stats_Review.pdf	2020 Price per unit
Green Chop Ensilage	Bill Verbeten, NW New York Dairy, Livestock & Field Crops. Converting Hay Prices to Haylage Values. Retrieved on May 6, 2024 from https://nwnyteam.cce.cornell.edu/submission.php?id=343	*Ensilage price is 40% of hay, all other (dry) price, assuming 40% dry matter
Hay, Organic	USDA National Organic Grain and Feedstuffs Report Agricultural Marketing Service, Grain and Feedstuffs Market Trend January 29,2020, https://esmis.nal.usda.gov/sites/default/release-files/j3860697r/ff365p00g/ff365p01r/LSBNOF.PDF	2020 average price
Napa Cabbage	Ag Marketing USDA Specialty Crop Report 1-9-23 Napa Cabbage	35 lb carton $36-37. 36.5/35 = $1.04 /lb.

Rye	USDA National Agricultural Statistics Service, Quick Stats, https://quickstats.nass.usda.gov/	2021 average price
Rye, Organic	Farmer Provided	
Soybean Organic	USDA National Organic Grain and Feedstuffs Report Agricultural Marketing Service, Grainand Feedstuffs Market Trend January 29,2020, https://esmis.nal.usda.gov/sites/default/release-files/j3860697r/ff365p00g/ff365p01r/LSBNOF.PDF	2020 average price
Sunflower s	USDA National Agricultural Statistics Service,Crop Values 2021 Summary, https://esmis.nal.usda.gov/publication/crop-values-annual-summary/2022-02-24	2021 average price
Tomatoes	USDA National Agricultural Statistics Service,Vegetables 2021 Summary, https://esmis.nal.usda.gov/sites/default/release-files/02870v86p/zs25zc490/9593vz15q/vegean22.pdf	2021 average price
Triticale	Manitoba Agricultural Services Corporation. (n.d.). *Crop Dollar Values (2026)*. MASC. https://www.masc.mb.ca/masc.nsf/crop_dollar_values.html	Converted to US Dollars at the 2021 IRS exchange rate of 1.254 and converted to the US triticale bushel weight of 50 lbs. from the Canadian standard 54 lbs. per bushel
Wheat, Organic	USDA National Organic Grain and Feedstuffs Report Agricultural Marketing Service, Grainand Feedstuffs Market Trend January 29,2020, https://esmis.nal.usda.gov/sites/default/release-files/j3860697r/ff365p00g/ff365p01r/LSBNOF.PDF	2020 average price
Wine Grapes	USDA National Agricultural Statistics Service California Field Office, California Grape Crush 2020 Final Report, https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Crush/Final/2020/2020_final_grape%20crush.pdf	2020 average price

Wine Grapes, CA all red varieties	USDA National Agricultural Statistics Service California Field Office, California Grape Crush 2020 Final Report, https://www.nass.usda.gov/Statistics_by_State/California/Publications/Specialty_and_Other_Releases/Grapes/Crush/Final/2020/2020_final_grape%20crush.pdf	2020 average price

Additional References:

Moebius-Clune, B. N., Moebius-Clune, D. J., Gugino, B. K., Idowu, O. J., Schindelbeck, R. R., Ristow, A. J., van Es, H. M., Thies, J. E., Shayler, H. A., McBride, M. B., Kurtz, K. S. M., Wolfe, D. W., & Abawi, G. S. (2016). *Comprehensive Assessment of Soil Health – The Cornell Framework, Edition 3.2*. Cornell University. https://cornell.app.box.com/s/3h14gp6oam1hfu1u1srab9n59deni896

Posit team. (2025). RStudio: Integrated Development Environment for R [Computer software]. Posit Software, PBC.

R Core Team (2025). _R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

Sullivan, D.M., Andrews, N., Brewer, L.J. 2020. Estimating Plant-Available Nitrogen Release from Cover Crops. Pacific Northwest Extension Publishing PNW636. Oregon State University. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw636.pdf

U.S. Department of Agriculture, Natural Resources Conservation Service. (2020). Cropland In-Field Soil Health Assessment Guide (Technical Note No. 450-06). https://www.nrcs.usda.gov/sites/default/files/2023-03/In-Field Assessment 2021 Complete ND.pdf