Conservation Evaluation and Monitoring Activity (CEMA) 204
Adaptive Management for Soil Health

Design Sheet

Producer:	______________________________	**Planner:**	________________________
Address:	______________________________	**County:**	________________________
Farm Name:	______________________________	**Date:**	________________________
Track/Field:	______________________________		

Overview

Adaptive management is the process of testing an idea through replicated field trials and assessing the results. Start by developing an idea, or hypothesis, and then think of a detailed experimental design that can test the hypothesis on the farm. Choose a conservation practice that addresses the identified resource concern and allows for a treatment to satisfy the requirements of the CEMA 204 activity.

See "Agronomy Technology Note No. 10, Adaptive Management for Conservation Practices" for additional details.

Practices Available for Adaptive Management for Soil Health Planning and Implementation	
311 Alley Cropping	379 Forest Farming
314 Brush Management	381 Silvopasture
315 Herbaceous Weed Treatment	420 Wildlife Habitat Planting
328 Conservation Crop Rotation	484 Mulching
329 Residue and Tillage Management, No Till	528 Prescribed Grazing
336 Soil Carbon Amendment	550 Range Planting
338 Prescribed Burning	590 Nutrient Management
340 Cover Crop	345 Residue and Tillage Management, Reduced Till

Testing the Idea

Every adaptive management project starts with an idea, or hypothesis, that needs to be tested. To improve farmer/rancher engagement, focus on ideas that have direct applicability to the grower’s goals and objectives. Make the idea into a statement, such as “No-till planting will improve soil organic matter.”

What is the idea (hypothesis) being tested?
For example: Does no till improve soil health measurements and yield compared to strip till in a wheat-soybean-corn rotation?

What treatments will be compared to test the idea?

	TREATMENT A		*TREATMENT B* †
This trial will compare	No Till	*to*	Strip Till

† *It is recommended that you establish a control treatment to simplify comparisons with baseline management.*

What conservation practice(s) will be implemented to test the idea? (listed above)
329 No Till
345 Reduced Tillage (strip till)

What additional conservation practices or activities will be implemented to test the idea?
Measure strip tilled and no till areas and test for soil health measurements
Measure seed germination and yield

Data Collection

→ Engage cooperative extension, conservation districts, crop advisors, and other partners to assist with data collection.

Identify what needs to be measured and what data should be collected. Be realistic about the amount of data to collect, narrow timing windows, required testing equipment, and cost of measured data. Complete the In-Field Soil Health Assessment for each treatment.

What measurements are needed to test the idea?

Measurement	*Test, Tool, or Method*	*Timing*	*Responsible Party*
Soil Health (SH) tests	Basic SH suite	June 1	QI

Germination	% germination rate	2 weeks after planting	Farmer & QI
Yield	Weight cart	At harvest	Farmer & QI
Other			

Experimental Design

Determine where on the farm you will conduct the field trials and how you will set up the replicated plots in the field. The project site should be uniform with respect to soils, slope, drainage, and other inherent soil properties. Also consider past management, drainage, grazing management, and irrigation. Avoid laying out plots along field edges and end rows as variability in those areas can skew the results.

Where will the Adaptive Management for Soil Health trials be conducted?			
Farm/Tract:	100/ 234	Total Field Acres:	40
Field #:	15	Plot Trial Acres:	2
x	Attach a map of the field(s) where the trials will be conducted.		

How will the replications in the Adaptive Management for Soil Health plot trials be conducted?

A replication is a repeated trial of an experiment. In adaptive management trials, each replication is typically comparing Treatment A to Treatment B for a T test analysis. If there are more than two treatments, use Analysis of Variance (ANOVA) analysis. Adding replications reduces the likelihood that the results will be influenced by chance and builds statistical validity.

See the graphic below to visualize the two treatments and four replications in a typical randomized plot trial layout.

Consider the width of planting, cultivation, spraying, and harvest equipment when determining plot widths. Plots typically consist of two planter or harvest widths.

Number of Replications:	3	← *Four or more replications are recommended. Each replication should be of similar or equal size.*
Replication Plot Size:	0.57 acre 50 ft. x 500 ft.	
Years Planned:	2026, 2027, 2028	← *Three years of trials on the same footprint is recommended to avoid the impact of weather and variability in site conditions.*
Same Footprint?	x YES NO	

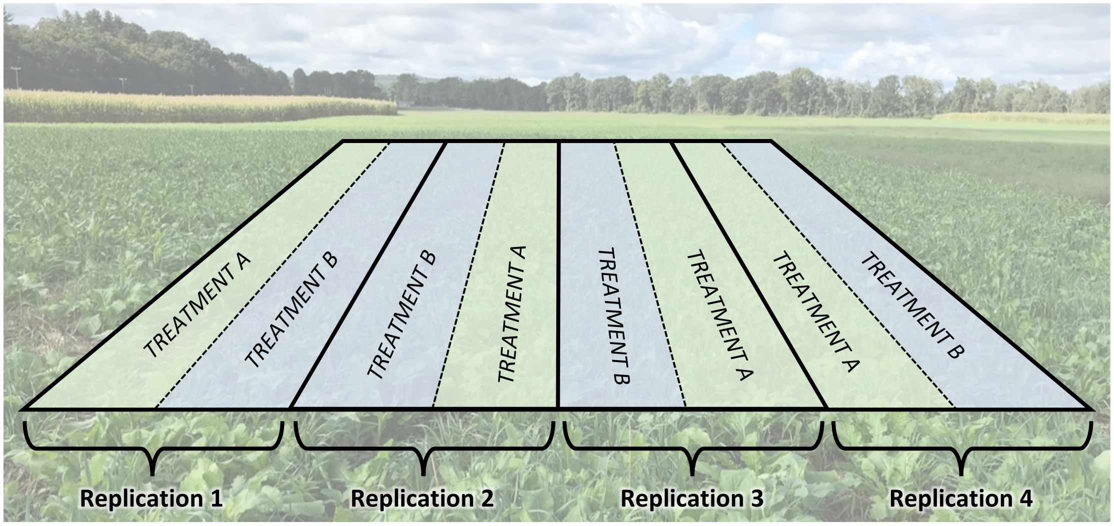
Typical Randomized Plot Trial Layout

The graphic below illustrates the typical layout of replicated trials in a crop field. Notice that each replication repeats the comparison of Treatment A to Treatment B. This reduces the likelihood that any one treatment will skew the results and builds the statistical validity of the trials.

Layouts may vary depending on the goals of the project, but the following are recommended:

- Choose a field(s) with similar inherent properties, such as soil type, slope, aspect, and drainage.

- Choose a field(s) with similar prior management, such as cropping or grazing history, nutrient additions, and herbicide applications.
- Avoid field edges, end rows, drive roads, and other areas of variability when selecting the site.



Typical layout of a randomized plot trial.

What is the cropping, grazing, or tree harvest history where the plot trials will be conducted?

Include all relevant details, such as timing, rates, yields, specific products, equipment used, and other factors that may impact production in the plot trials.

Crop(s): ___Wheat, Corn____

Rotation Schedule: _____Wheat, Corn ____

Tillage or Stocking: _____Strip Till and No till Planter____

Planting Methods: ____________JD planter_____________________________________

Pesticides Applied: ____

Nutrients Applied: _______175 lbs Nitrogen____

Harvest Methods: ______combine 8 row header ____

Cover Crops: ______none______________

Irrigation: ________pivot____

Other Information: ________spray pre plant to kill weeds _____________

____

What are the soils and site conditions where the plot trials will be conducted (refer to Web Soil Survey)?

Soil Map Unit: ___________MjG____

Slope: ___________3%____

Drainage Class: ____

Drainage Systems:	____
Irrigation Systems:	__________None__________________________________
Other Information:	_______Pivot____________________________________
	____

Pre-Trial Preparatory Work

Include any preparatory work or measurements required to make the site suitable for trials, such as plot layout, tillage, seedings, fertilization, etc.

TREATMENT A		*TREATMENT B*	
WORK REQUIRED	MEASUREMENT REQUIRED	WORK REQUIRED	MEASUREMENT REQUIRED
Flag 50 x 500 plots replicated 3 times for No till	Soil health tests, yield bu/ac	Same for Strip till	Soil health tests, yield bu/ac

TREATMENT A		*TREATMENT B*	
Spring			Year: _________
WORK REQUIRED	MEASUREMENT REQUIRED	WORK REQUIRED	MEASUREMENT REQUIRED
Summer			
Fall			
Spread residue with combine		same	
Winter			

Spring WORK REQUIRED	MEASUREMENT REQUIRED	Year: ____1_____ WORK REQUIRED	MEASUREMENT REQUIRED
No till test plots, then plant corn with JD planter		Strip till, then plant corn in test plots with JD planter	
Summer			
Take soil health tests from 6 plots		same	
Fall			
Calculate yield from each of 6 plots		same	
Winter			

Spring WORK REQUIRED	MEASUREMENT REQUIRED	Year: _________ WORK REQUIRED	MEASUREMENT REQUIRED
Summer			
Fall			
Winter			

Participant's Signature: ___________________________________ Date: ____________

Certified By: ____ Date: ____________

Frequently Asked Questions

How do you define CEMA 204 and what land uses are applicable?

CEMA 204 is the evaluation and monitoring of soil health management strategies to inform conservation planning. Land uses include crops, forest, pasture, and rangeland.

When would a producer consider implementing CEMA 204 for their operation?

Soil health adaptive management is applicable to growers that are already using a given practice but want to improve the effectiveness of the practice. It is also helpful to producers using practice for the first time to learn how best to apply that practice on their own unique landscape using their own management style.

What is the strength or positive outcome of Adaptive Management for Soil Health?

Producers do not have to rely on offsite meta-analysis of data to perform on-farm comparative research; they are better able to make farm decisions within the context of their own operation. Adaptive management using the on-farm field trials protocol enables growers to make well-informed and documented decisions on how to adjust their management to be more profitable and sustainable. The protocol helps the grower establish and test a hypothesis in consideration of the biological processes taking place in their fields. The process provides an analytical method for determining if there is significant difference between the existing and proposed treatments.

What or who is a qualified individual for this CEMA 204?

A qualitied individual for Adaptive Management for Soil Health is one of the following:

- Certified Crop Advisor (CCA) or Certified Professional Agronomist (CPAg) from the American Society of Agronomy
- A Certified Professional Soil Scientist (CPSS) or Associate Professional Soil Scientist (APSS) through the Soil Science Society of America
- An Extension Specialist from a Land Grant University or affiliated with an institution of higher learning with a focus on agriculture, range, or soil science
- A person who has a bachelor's degree or higher in an agricultural, range, forestry, or soil science field and has at least 2 years of experience using the scientific process to answer questions (including experimental design, data collection, and analysis)

How can planner and producer be more consistent with the research project?

When using this activity to monitor practice effects over multiple years, the following are recommended: use the same georeferenced locations, employ the same sampling strategy, collect soil samples under similar soil conditions and at the same time of year, use the same lab tests and methods, and use the same laboratory. Keep projects simple to prevent errors or project failures. Start small, using a uniform field that is big enough to implement results of research, and then expand those practices to further test scalability and profitability.

What soil samples are required for CEMA 204?

Refer to CEMA 216 Soil Health Testing for guidance on selecting soil health indicators using quantifiable measures of biological, chemical, and physical characteristics of soils. At a minimum, measure/analyze soil organic carbon by dry combustion, pH, and wet macro-aggregate stability in addition to characteristics identified in the purpose of the conservation practice being evaluated. In year one, analyze soil texture.

What possible practices are associated with CEMA 204?

- 311 Alley Cropping
- 314 Brush Management
- 315 Herbaceous Weed Treatment
- 328 Conservation Crop Rotation
- 329 Residue and Tillage Management, No Till
- 336 Soil Carbon Amendment
- 338 Prescribed Burning
- 340 Cover Crop
- 345 Residue and Tillage Management, Reduced Till
- 379 Forest Farming
- 381 Silvopasture
- 420 Wildlife Habitat Planting
- 484 Mulching
- 528 Prescribed Grazing
- 550 Range Planting
- 590 Nutrient Management

What are the major technical requirements for completing CEMA 204?

1. Formulate a question that can be tested simply and effectively. Record the purpose and strategy (hypothesis: "If I make this change, I expect these results") for the evaluation.

2. Determine the resources needed to carry out the plot comparisons, such as equipment to establish, manage, and monitor the plot comparisons. Match equipment widths.

3. Plan the replicated plot trials:

   a) Select locations that are equivalent in size and other characteristics (e.g., soil texture, management history). Know the field history to avoid conducting a trial in an area where variability is high or something else may affect the results.

   b) Include a control treatment to test other treatments or compare two treatments.

   c) Have a minimum of 3 replications of each treatment (6 total plots) for confident T-test analyses and to account for field variability. Randomize the placement of these replicates to avoid any conditions that may confound your results.

   d) Select the location and map out the replicated field plots. Typically, the most limiting piece of equipment or management criterion will dictate the width or area of the plot. Plots must be laid out where soils (map unit), fertility, slope, and drainage are as uniform as possible.

   e) Follow all USDA-APHIS regulations for prohibited, regulated, or quarantined soils.

   f) Complete In-Field Soil Health Assessment for each treatment (e.g., Soil Health Technote No. 470-06) at the beginning of project and after 3 years, at the end of the project, in each replication.

   g) Schedule and install the operations needed for the control and the proposed treatment factors. Make observations and keep notes throughout the season.

h) Collect the data. Record all monitoring data and other associated variables as needed. It is recommended that you keep duplicate records (i.e., paper data sheets *and* a digital version) in case something happens to one data file.

i) Include soil health indicators with associated protocols. Verify laboratories are certified by *one* of the following:

- The Performance Assessment Program (PAP) from The North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America
- The American National Standards Institute (ANSI) National Accreditation Board (ANAB)
- The International Organization for Standardization (ISO/IEC 17043:2010) for ISO 10694:1995
- A State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results

j) Statically analyze the data. You can use your local extension agent, qualified individual (QI), technical service provider (TSP), or any person with experience interpreting data.

k) Summarize data, interpretations, and conclusions into a final report.

What should be included in the Methods section of the report?

1. Study design and sampling strategy descriptions, including test types.

2. Adaptive Management Design Sheet completed as directed.

3. Complete In-Field Soil Health Assessment for each treatment (e.g., Soil Health Technote No. 470-06).

4. In-field measurements and laboratory test results. Possible results include wildlife counts, percent germination, plant establishment success, yield, ground cover, pest control, water infiltration, soil health testing, and soil aggregate stability. Some practices may require multiple measurements throughout the year.

5. Statistical analysis: T-test or ANOVA, or other tests as appropriate to the research questions, study design, and data types.

What should be included in the Results section of the report?

1. Discussion about the findings or results.

2. Interpretations and conclusion. What was the effect of the treatment on the soil health indicator(s)? What was learned?

3. Producer statement of intention, to adopt or reject the treatment for future management. Explanation of decision should include any concerns, such as ease/difficulty of the change, impacts on workload and time spent to adopt treatment, yield change in cash crop, or cost and benefits of the comparison.

Is there an Implementation Requirement document?

No. However, there is a design sheet that needs to be completed. Documentation of statistical analysis will be included.

How many replications are required?

Three (3) replications are a minimum, but 4 are recommended. See design sheet for examples of a replicated trial with 2 treatments.

What statistics are required?

A simple T test (see associated stats page) that compares two treatments is adequate. Calculate the least significant difference (LSD) for the replicated trial. For more complicated comparisons the QI can use ANOVA to calculate an LSD value.

Land Use Examples

1. *Cropland* in a randomized design comparing two cover crop treatments: One treatment is a monoculture planting, and the other is an 8 species mix. Treatments would be planted after wheat harvest, with the next crop being grain corn. Comparison focuses on 3 years of soil health measurements and corn yield.

2. *Cropland* in a randomized design comparing two residue management treatments: One treatment is strip till in the fall, and the other is no till in the spring. The previous winter crop is wheat, and the planted crop is corn. Comparison focuses on 3 years of soil health measurements and yield.

3. *Rangeland* in a randomized design comparing two brush management treatments: One treatment is mechanical (shredder/ chopper) to kill unwanted brush. The other treatment uses airplane-applied herbicide spray to kill the unwanted brush. Brush is managed to meet the objectives of the landowner. Brush density exceeds desired levels based on ecological site potential. The area has excessive stands of woody species that degrade health and vigor of native herbaceous species; the conditions promote the growth of noxious and invasive species and degrade soil health. After sufficient time has passed, post-treatment regrowth of target species is evaluated and the situation is monitored. The line-point interception method is used to gather data. Comparison focuses on soil health using the Rangeland In-Field Soil Health Assessment tool.

4. *Rangeland* in a randomized design comparing two range plantings: One treatment uses grasses only (minimum of two species). The other treatment uses a mixture of adapted warm-season grasses, cool-season grasses, warm-season forbs, and cool-season forbs where applicable. The practice is applied where desirable vegetation is below the acceptable level for natural reseeding to occur. Species selected for richness and/or diversity must be compatible with ecological site descriptions and management objectives. Items needed to assist in-stand establishment are identified. Plant production and species composition are compared by estimating and harvesting a plot as outlined in the *Range and Pasture Handbook*, Subpart E. Comparison focuses on soil health using the Rangeland In-Field Soil Health Assessment tool.

5. *Rangeland* in a randomized design comparing two brush management treatments: One treatment is mechanical (shredder/ chopper) to kill sage brush. The other treatment uses airplane-applied herbicide spray to kill brush. The line-intercept method is used to compare dead brush plants. Yearly survival rates and soil health measurements are also compared.

6. *Rangeland* in a randomized design comparing two range plantings: One treatment is a two-species planting. The other treatment uses an eight-way perennial mix. The line-intercept method is used to compare diversity of plants. Yearly survival rates and yearly biomass are also compared.

7. *Forestland* in a randomized design comparing two herbaceous weed treatments: One treatment is a low-cost, short-lived chemical application (2,4-D). The other treatment is a longer-living application, such as Milestone herbicide. Comparison focuses on yearly survival rates of targeted weeds and soil health measurements.
8. *Forestland* in a randomized design comparing two prescribed burn treatments: One treatment is a spring, low intensity burn. The other treatment is an early fall, high intensity burn. Comparison focuses on yearly survival rates of targeted brush weeds.
9. *Forestland* in a randomized design comparing two prescribed burn treatments: One treatment is a 1-year (annual) burn; the other treatment is a 3-year burn. Comparison focuses on yearly survival rates of targeted brush weeds.

10. *Pastureland* in a randomized design comparing two stock density treatments: One treatment uses 1,000 pounds per acre; the other uses 40,000 pounds per acre. In both cases, the forage is grazed to the recommended grazing height. Soil health as well as plant cover, residue cover, plant diversity, and nutrient management are compared. The point-step intercept method is used to collect data.

11. *Pastureland* in a randomized design comparing residual grazing heights/dry matter weight treatments: One treatment uses the recommended residual grazing height/weight (e.g., tall fescue 4 inches or higher); the other treatment uses half the recommended residual grazing height/weight (e.g., tall fescue 2 inches or shorter). Comparison focuses on soil health as well as plant cover, residue cover, plant diversity, soil aggregate stability, and plant vigor and productivity. The step-point intercept method is used to collect data.

12. *Pastureland* in a randomized design comparing different recovery periods: Both treatments have the same stocking rate for the farm, but one treatment uses roughly a monthly rotation and the other uses a twice a week rotation. Paddock sizes and grazing period will likely vary. The actual rotation is based on 80 percent or more of the residual grazing height being at the recommended ending height (e.g., 4 inches for tall fescue). Comparison focuses on soil health as well as plant cover, residue cover, plant diversity, soil aggregate stability, and plant vigor and productivity. The step-point intercept method is used to collect data.

13. *Pastureland* in a randomized design comparing the effect of forage diversity on soil health: Both treatments are well managed; minimum grazing heights and plant recovery are maintained. One treatment is grass only. The other treatment is a mix of grass, legumes, and forbs, in which each functional group makes up a minimum of 15 percent of the stand. Pastureland planting and herbicides or other mechanical control are used to maintain the two treatments. Comparison focuses on soil health (including soil aggregation) as well as plant cover, residue cover, and plant vigor and productivity. The step-point intercept method is used to collect data.

CEMA 204 Adaptive Management for Soil Health

Final Report

Name:

Qualified Individual:

Date of Report:

1. Introduction of adaptive management project
2. Hypothesis
3. Study design, replications, sampling descriptions
4. In-field soil health assessment information
5. Laboratory results for soil health measurements
6. Field results (i.e., yield)
7. Statistical analysis used and T-test or ANOVA
8. Discussion about findings or results (Were treatments statistically different?)
9. Conclusions
10. Producer statement of intention to adopt or reject the treatment for future management