Pasa SUSTAINABLE AGRICULTURE | Research

Soil Health Benchmark Study:

Methods Guide for Research Collaborators

Updated May 2022

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Introduction

The Soil Health Benchmark Study is an innovative community science project that enables farmers to work collaboratively to grow their farms' soil health—and advance our collective understanding of how farming practices and weather patterns can degrade or enrich soil over time.

The study was developed by Pasa Sustainable Agriculture (Pasa) in 2016. Today, Pasa continues to administer the study in collaboration with more than 120 vegetable, pastured livestock, and row crop farmers and partners including the Bionutrient Institute, Cornell Soil Health Laboratory, Future Harvest and the Million Acre Challenge, Maine Farmland Trust, Penn State Extension, Rodale Institute, Stroud Water Research Center, OurSci, and OpenTEAM.

In 2020, we expanded the scope of this project to also measure water resilience in soil, which is closely linked to soil health and mitigating sediment and chemical pollution in streams, rivers, bays, and other bodies of water. A subset of vegetable farmers also started submitting crop samples for nutrient density testing by the Bionutrient Institute, part of the Bionutrient Food Association, to show the relationship between nutrient density levels and soil health management practices. We hope to expand this work to other production systems.

In 2021, a subset of row crop farmers began submitting additional data to uncover the most cost effective soil health management strategies.

Farmers can participate in the Soil Health Benchmark Study in two ways:

- **Research collaborator:** Farmers who join our project as a research collaborator contribute soil tests and detailed farm management records to our ongoing project using a rigorous set of methods. A limited number of farmers are eligible to join the project as research collaborators. To generate useful soil health data for analysis, we strive to enlist a core group of research collaborators who collectively represent a diverse array of farms and farming methods. Our project includes more than 100 farmers within three cohorts: vegetable farms, row crop and grain farms, and pastured livestock and grazing dairy farms.
- **Community scientist:** To accommodate growing interest, we expanded the project to allow farmers to participate in parts of the project as community scientists. There is no limit to the number of farmers who can participate as community scientists, who collect their own soil samples and compare their measurements to our research benchmarks. Since there is less controlled data collection and oversight for community scientists, we log this data separately from the data we collect from research collaborators.

About this guide

This guide is for **research collaborators** participating in our Soil Health Benchmark Study. You'll find all the information you need to participate in our project, including how to select research fields, take accurate soil samples, and, if applicable, how to take water resilience measurements. It also reviews what basic field management records we need for this project.

Farmers not participating in our project, and other agricultural professionals, can also use this guide to learn about our methods. Our methods were developed with input from participating farmers and scientists at Pasa, Penn State University, Cornell University, and Stroud Water Research Center.

What data do we collect?

To get an overall assessment of each farm's soil health, research collaborators choose three production fields that will double as research fields. These three fields should represent your typical crop rotation or major production land uses. Research collaborators contribute data every year they participate in the project from these fields in three ways:

- **Required:** Sample soil during the fall. These samples are analyzed using Cornell University's Comprehensive Assessment of Soil Health Test.
- **Required:** Maintain field management records that track relevant information like crop rotations, tillage and equipment activity, soil amendments, and animal grazing events.
- **Optional:** Farmers working with Pasa can measure field water resilience through infiltration testing.

With this data, we develop quantifiable soil health indicators specific to your farm, and benchmark your soil health indicators with peer farmers in an annual, custom benchmark report. You can use your custom benchmark report to evaluate and improve your farm's soil health management practices, and to collaboratively engage with other project participants to discuss soil health management strategies and to develop practical solutions to soil health issues.

Pasa and organizational partners publicly share data collected through this project during workshops and in presentations, and in publications. Farm names and identifying information are kept anonymous.

Selecting research fields

With guidance from staff members, research collaborators choose three production fields that correspond to phases of a typical crop rotation or represent the farm's major production land uses (Figure A). These fields should be typical performers within your farm's operations, and not skew to either poor or exceptional performance. Fields should also represent the typical soil type and topographic positions of your farm.

Below are examples of research field selections for each cohort within the study:

- **Vegetable farm:** If your farm practices a three-year vegetable rotation involving fall brassicas in year one, tomatoes and peppers in the next year, to a full year of cover crops, the research fields should each be in one of these rotational phases.
- **Grazing or pastured livestock farm:** If your farm is divided into roughly a third permanent pastures, a third hay fields, and a third annual crops, each research field should represent one of these production uses.
- **Row crop or grain farm:** If your farm practices a six-year crop rotation involving two years of corn silage, to one year of soybean, to three years of alfalfa, the research fields should represent a field in first year corn, a field in soybean, and a field in second year alfalfa.

Figure A. These three research fields represent different phases of a pasture and annual cropping rotation.

Soil health indicators

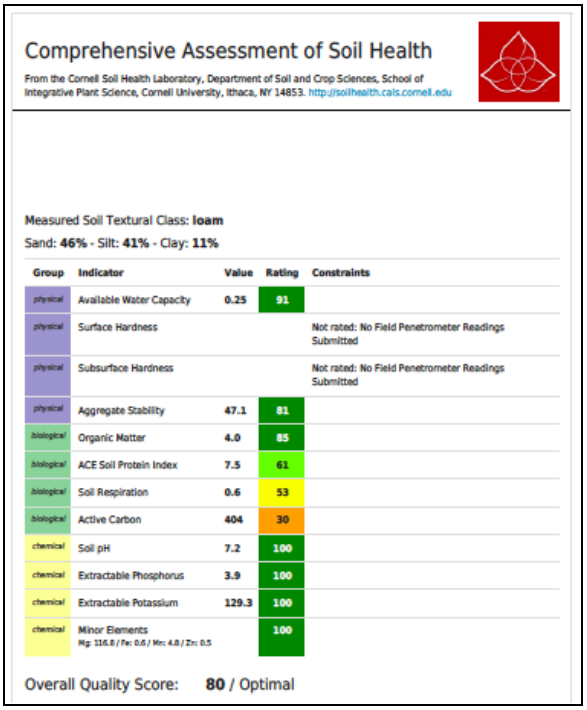
Research collaborators submit all soil samples to the Cornell Comprehensive Assessment of Soil Health laboratory, a national leader in soil health science. Soil samples are tested for a total of 10 different chemical, physical, and biological indicators (details on page 7).

Using the Cornell Comprehensive Assessment of Soil Health

All research collaborators receive a comprehensive report from the Cornell Soil Health Lab (Figure B). In addition to receiving the lab value for each measured indicator, Cornell rates each value on a 100-point scale relative to thousands of other samples with similar soil textural classes, making it possible to compare samples from different soil types using a common framework (see rating scale to right).

An overall score is also calculated for each farmer's soil sample by averaging the individual indicator ratings. The overall score can be a useful general summary, but individual indicators will be more useful in identifying strengths or management challenges for a specific field.

OPTIMAL (80-100)
EXCELLENT (60-80)
AVERAGE (40-60)
LOW-LEVEL (20-40)
CONSTRAINED (0-20)



Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Measured Soil Textural Class: **loam**

Sand: **46%** - Silt: **41%** - Clay: **11%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.25	91	
physical	Surface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Subsurface Hardness			Not rated: No Field Penetrometer Readings Submitted
physical	Aggregate Stability	47.1	81	
biological	Organic Matter	4.0	85	
biological	ACE Soil Protein Index	7.5	61	
biological	Soil Respiration	0.6	53	
biological	Active Carbon	404	30	
chemical	Soil pH	7.2	100	
chemical	Extractable Phosphorus	3.9	100	
chemical	Extractable Potassium	129.3	100	
chemical	Minor Elements Mg: 116.0 / Fe: 0.6 / Mn: 4.8 / Zn: 0.5		100	

Overall Quality Score: **80** / Optimal

Figure B. An example of the soil test results that research collaborators receive from the Cornell Soil Health Lab.

Cornell's soil health indicators

Below is a summary of the soil health indicators measured by Cornell University's Comprehensive Assessment of Soil Health. You can learn more about Cornell's soil health test here.

Physical soil health indicators

- **Available water capacity** is a measure of the amount of water accessible to plant roots relative to the total amount of water the soil can hold under saturated conditions. Soils with greater available water capacity allow plants to perform better under drought conditions. It is measured in units of grams of water per gram of dry soil.
- **Aggregate stability** is a measure of the extent to which soil structure can hold up to wind, rain, and other stresses. Good aggregate stability helps promote germination and root growth. It is measured as the percentage of soil aggregates that hold together through a standardized rainfall simulation.

Biological soil health indicators

- **Organic matter** is a core measurement of soil health—it is the foundation of soil life, helps form stable soil aggregates, helps improve available water capacity, and provides a slow-release supply of nutrients. It is measured as the percent of total soil mass that contains carbon compounds derived from living or once-living biomass.
    - **Total carbon** is a measurement of both inorganic and organic forms of carbon present in the soil. Soil inorganic carbon is bound in minerals like calcium carbonate or lime. Soil organic carbon consists of active carbon sources and more stable organic carbon found in the soil. Total carbon and soil organic carbon can be more precise indicators for organic matter composition.
    - **Total nitrogen** is a measurement of both inorganic and organic forms of nitrogen present in the soil. Because most total nitrogen is bound in soil organic matter, this can indicate if there is sufficient nitrogen contained in the organic matter for soil microorganisms. If levels aren't sufficient, soil microorganisms can outcompete plants for inorganic nitrogen also known as immobilization.
- The **Soil Protein Index** conveys the amount of protein contained in soil organic matter. Proteins contain substantial amounts of nitrogen. Microbes in the soil can break down these proteins, making the nitrogen available to plants. Soil protein is measured as milligrams of protein extracted per gram of soil.
- **Soil respiration** measures the abundance and activity of microbial life in the soil. Soil

microbes work to break down plant residues in the soil, and cycle nitrogen and other nutrients from organic matter into plant-available forms. As they break down organic matter, microbes release carbon dioxide, so microbial activity can be measured by capturing the carbon dioxide produced by soil microbes over a four-day incubation period in the lab. Respiration is expressed in units of milligrams of carbon dioxide per gram of soil.

- **Active carbon** is a measurement of the small portion of soil organic matter that can serve as an easily available food source for soil microbes, thus helping maintain a healthy soil food web. Active carbon is a leading indicator of biological soil health, and tends to respond to changes in soil management earlier than total organic matter content. It is measured in parts per million.

Chemical soil health indicators

- **pH** is a measurement of how acidic the soil is, which controls how available nutrients are to crops. If pH is too high, nutrients such as phosphorus, iron, manganese, copper, and boron become unavailable to the crop. If pH is too low, calcium, magnesium, phosphorus, potassium, and molybdenum become unavailable. The value is presented in standard pH units, and rated using a hump-shaped curve. A pH between 6.2 and 6.8 is optimal for most crops.

- **Phosphorus** is an essential plant nutrient. It is used by plant cells to build DNA and regulate metabolic reactions. At high levels, phosphorus can become a risk to water quality, and at very high levels it can interfere with plant uptake of micronutrients, including iron and zinc. Note that Cornell scores phosphorus measurements using a hump-shaped curve, such that both low and high parts per million (ppm) values get ratings toward zero. Optimal values for phosphorus vary based on the texture and geology of individual soil types, but ratings above 30 ppm are typically considered excessive.

- **Potassium** is an essential plant macronutrient that contributes to heat and cold tolerance. It also promotes fruit development in horticultural crops. It is measured in parts per million by mass.

- **Minor elements** including magnesium, iron, manganese, and zinc are essential for various plant biochemical reactions but are required in small quantities. If any minor elements are deficient, this will decrease yield and crop quality. Toxicities can also occur when concentrations are too high. Cornell provides individual measurements in parts per million for each of these four minor elements, but aggregates all four into a composite minor element rating.

How to sample soil

Our soil sampling protocol is adapted from Cornell University, and is specifically designed for taking soil samples to submit to the Cornell Comprehensive Assessment of Soil Health laboratory. Each research collaborator consistently adheres to the following soil sampling procedures each year they participate in the study so that we can accurately compare data.

During the first year a farm participates in this study, a staff member visits to conduct the soil sampling while training research collaborators on the proper procedures. During the following years, research collaborators follow the instructions below to conduct the sampling themselves.

The following pages provide detailed instructions on taking accurate soil samples.

We also created a short instructional video to demonstrate proper sampling procedures and complement the written instructions.

STEP ONE: Plan when to sample soil.

- Take soil samples from mid-October through mid-November, if weather and field conditions allow. Collect samples from all three research fields on the same day.
- Avoid taking samples at times when the soil is too dry (and difficult to get a shovel into), or saturated and muddy. A good rule of thumb is if the soil is workable and able to be tilled, it's a good time for soil sampling.
- Other guidelines by farm or field type:
    - **Vegetables:** If a cover crop will be planted in the field being sampled, take the sample *after* the cover crop has been planted (and after any field prep operations).
    - **Grains, row crops, and forage crops:** Take the sample after grain or silage has been harvested, or after the last cutting of hay. If a cover crop or forage crop will be planted in the field being sampled, take the sample *after* the cover crop has been planted (and after any field prep operations).
    - **Livestock pastures and paddocks:** There are no additional guidelines for taking soil samples in these fields.

If field and weather conditions allow it, the best time to take soil samples is sometime between mid-October and mid-November.

STEP TWO: Take the samples.

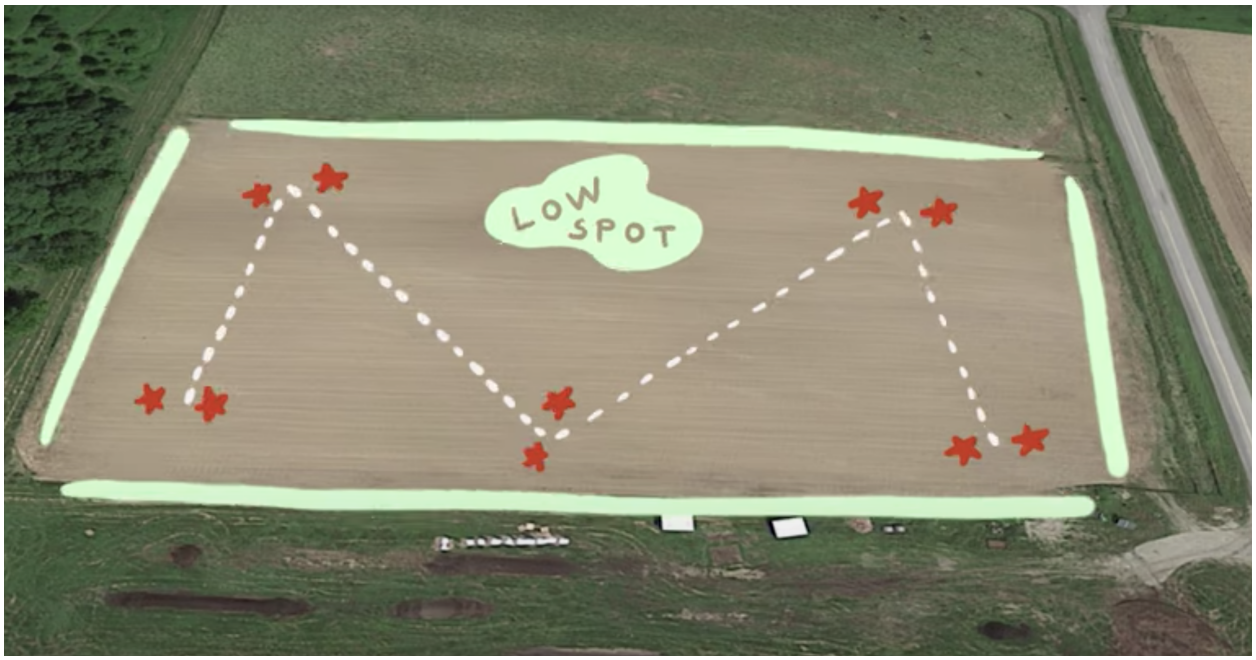
1. **Collect the following supplies:**

- Straight shovel (see image to right), such as a sharp-shooter or drain-spade style. *Note: A straight shovel helps to ensure you collect an even amount of soil along the 6in profile of the sample. If you must use a pointed-tip shovel, take extra care to follow step 3-C and 3-D below to take an even profile of soil.*
- Ruler or tape measure
- One 5-gallon bucket
- Permanent marker
- Measuring cup (1 cup)
- *Provided by Pasa or organizational partners:* Two 1-gallon freezer storage bags for each field being sampled (six bags in total)
- *Provided by Pasa or organizational partners:* Prepaid shipping box
- *Provided by Pasa or organizational partners:* Cornell Soil Health Test submission form

2. **Carefully choose 10 sampling locations within each of the three research fields** (30 total locations in total) **by doing the following:**

    A. For each research field, walk the length of the field and visualize ten locations for soil sampling. Choose five pairs of locations, with each location in a pair five to ten ft. apart. Locations should fall along an M-shaped path across the field. Avoid field borders and any irregular areas or "trouble spots," such as a low spot or rock outcropping. (See image below.)

    B. **For fields in vegetable production *at the time of sampling:*** Choose one location from each pair in a crop row and one location in a pathway. However, if the system involves permanent beds (i.e. the field is not tilled or rotated as a whole unit), choose both locations from a pair within the permanent bed.



The dotted line indicates an M-shaped walking path for determining sampling locations. The stars indicate ten soil sampling locations. Avoid irregular areas, like low spots, for sampling.

3. **Dig the soil sample.**

   A. Remove surface debris around the sampling location.

   B. Use a spade or shovel to dig a small hole about **8 in. deep** and **8-10 in. wide**.

   C. From the side of the hole, position the spade or shovel at a 90 degree angle to the ground and take a vertical, rectangular slice of soil 6 in. deep and about 2 in. thick. *To make the sampling process easier, mark a 6 in. line on the shovel before sampling.*

   D. Remove any extra soil hanging past the sides of the spade or shovel to ensure that the sample is the same width at the top and bottom of the slice. You want to end up with a rectangular, 6 in. deep x 2 in. thick slice of soil, the same width of the shovel or spade. *For accurate test results, it is important to collect the same amount of soil through the 6 in. sample profile so that your sample is not biased with more soil from the surface compared to the subsurface.* If you need to use a pointed-tip shovel, take extra care to collect an even, rectangular slice of soil.

E. Slide the slice of soil into your bucket.

F. Repeat steps A through E at each location within the field. Add each sub-sample from the same field to the same bucket. **Mix the samples in the bucket as you go, breaking up soil clods larger than an acorn with your hands. Do not mix samples from different research fields!**

G. Thoroughly mix the sub-samples together from the ten locations one last time, breaking up any remaining soil clods. Transfer about six cups of soil to a 1-gallon ziplock bag. We recommend using a measuring cup so you are not sending more soil than what is needed. Or, a large handful is also about a cup. Return any excess soil to the field, and clean the bucket out with your hands or a brush before moving on to the next field. Use a permanent marker to clearly label the ziplock bag with the **Field Name**, **Sampling Date**, and the **Farm's Name**.

Repeat all of the steps above for the two remaining research fields!

STEP THREE: Pack and ship your three samples.

1. Keep the soil samples away from direct sunlight. While you don't need to refrigerate them, please keep them near room temperature. They should be shipped within 1-3 days from when they were collected in the field.
2. Double bag each sample with two ziplock bags. Double check to make sure each sample is clearly labeled with **Field Name, Sampling Date, and Farm Name**.
3. Place the samples in the shipping box.
4. Complete the Cornell Soil Health Test submission form by filling in **the date sampled**. *All other necessary information on this form has been pre-filled for you.*
5. Place the Cornell Soil Health Test submission form in its own ziplock bag to protect it during shipping. **Then, place the form in the shipping box** on top of the samples.
6. Take the box to the nearest shipping facility and mail it to the Cornell Soil Health Lab:

Cornell Soil Health Lab
G01 Bradfield Hall
306 Tower Rd.
Ithaca, NY 14853

7. Get in touch with your study coordinator to let us know that you've shipped your soil samples!

Maintaining field management records

Throughout the calendar year, research collaborators maintain field management records for each of their three research fields on (1) soil disturbance and equipment activity, (2) planting and termination dates, (3) soil amendments, and (4) animal and grazing activity. These are standard records that many research collaborators are likely already maintaining. *Maintaining field management records is required for research collaborators.*

How to maintain (and submit) field records

You have several options for maintaining and submitting field records. Records can be maintained and submitted using an online survey tool, template forms that we provide, or your own digital or paper records, so you do not have to change your record-keeping system.

- **Preferred method: Submit your records using an online survey tool through SurveyStack.** *All farmers with an email address receive an invitation to join this web platform to access the survey.*

  Why use this method: You can access your survey throughout the year using your desktop computer or smartphone to enter your field management records. This tool uses the same format as our other record templates, but there are also features that make entering your records easy—like drop down selection boxes and the ability to quickly copy similar entries. We're also able to more quickly organize and analyze your records, which means we can send you insights and reports sooner!

  If you would like guidance in submitting your field management records through SurveyStack, please reach out to Pasa's research fellow Jeanne Lurvey, jeanne@pasafarming.org; 814-349-9856 x722.

- **Alternative method: Use our field management record templates.**
  - For downloadable electronic record templates or printable record templates, please visit the soil health research collaborator webpage: https://pasafarming.org/soil-health-research-collaborators/
  - For print copies to be mailed to you, please reach out to your study coordinator. (for Pasa: sarah@pasafarming.org; 814-349-9856 x706 or jeanne@pasafarming.org; 814-349-9856 x722)

- **Alternative method: Use your own records.** If you are submitting your own records, please review the field records protocol to make sure that all necessary information is provided.

Improve your record keeping with farmOS: With this flexible, online record keeping system, you can keep track of all your records throughout the year, and then send us the necessary information at the end of the season. Contact Jeanne, Pasa's research fellow (jeanne@pasafarming.org; 814-349-9856 x722) for more information.

What field records to keep

Please see Appendix A for examples of field management record tables and detailed notes. Here is an overview of what should be included in the field management records for each designated research field:

1. **Soil disturbance and equipment activity:**
    a. **All fields:** These records include all tractor or human-powered equipment and machinery that enter each research field and can cause compaction or can disturb the soil in some way. This includes all tillage equipment, planters, harvesters, cultivators, sprayers, mowers, and human-powered equipment like cultivation hoes. We request details including the model and make of the equipment, the approximate tillage depth and an approximate speed (in miles per hour)of each tractor event. When making multiple passes, record each individual pass as a separate soil disturbance or equipment activity event.
2. **Planting and termination dates:**
    a. **All fields:** These records include planting and termination dates for cash crops and cover crops in all research fields, including any perennial covers or cover crops overwintered from the previous fall. If known, please approximate winter kill dates for the appropriate cover crops. Please include the species for any cover crop mixes or if available, the commercial brand name of the mix.
    b. **Vegetable fields:** These records should focus on in-field operations only—transplant seeding dates in the greenhouse are not necessary to record for this study.
    c. **Row crop fields:** These records should also include crop yields, seeding rates, and seed prices.
    d. **Fields or paddocks in livestock pasture:** Perennial pasture establishment and pasture reseeding should also be noted in these records.

3. **Soil amendments:**

    a. **All fields:** These records include all soil amendments applied to research fields, including manure, compost, lime, mulch, and purchased fertilizers. This also includes any soil amendments added through irrigation systems or amendments applied as a foliar spray. We request the full product name and analysis results for any manure or compost products applied on these fields, if available.

    b. **Vegetable fields:** These records should focus on in-field operations only—amendments added to potting mixes for transplant production are not necessary to record for this study.

    c. **Fields or paddocks in livestock pasture:** At this time, we do not ask for records of manure deposited by grazing or pastured animals. Any bale feeding in pastures or paddocks should be included. The addition of manure from a barn, storage tank, or sourced from another farm should be included in these tables.

4. **Grazing and pasturing events:**

    a. **Fields or paddocks in livestock pasture:** These records include grazing and pasturing events in all research fields, including the number and type of livestock, and time spent in a field or paddock.

5. **Spray Records *(Row crop farmers only)*:**

    a. For all row crop fields, we are asking for spray records to be used for a new soil health economic benchmarking project. This includes 1) pesticides used for crop burndown, weed control, or pest and disease problems and 2) adjuvants, surfactants,or stabilizers. Please include date, full product name, and total amount applied before dilution.

Calculating soil health management indicators

We use the field management records research collaborators submit to us to calculate three soil health management indicators for each research field (see Appendix B to learn how we calculate these indicators). These indicators provide a snapshot of some of the farm management practices that most influence soil health in positive or, potentially, negative ways.

1. From soil disturbance and equipment activity records, we calculate a **tillage intensity index**. Tillage can be a valuable tool for weed management and incorporating cover crops, but it can also degrade soil structure and organic matter.

2. From planting and termination date records, we calculate the **days of living cover**. Living vegetation protects soil from wind and water erosion while also supplying the soil with fresh organic matter and supporting the microbiology population with necessary food.

3. From soil amendment records, we calculate the amount of **organic matter inputs**. Organic matter inputs can jump-start the formation of soil organic matter, add microbiology to the soil, and supply macro and micro nutrients. However, continuous inputs can also contribute to soil health challenges, such as excessive nutrient levels.

Measuring Water Resilience

The more **water resilience** soil possesses, the better it can provide important services, like water absorption and retention during varying and uncertain climate conditions.

Data to measure water resilience are collected through *double infiltration rings* filled with water to measure the infiltration rate at a select number of soil sampling locations. One out of a farmer's three research fields is designated for water resilience measurements. *Note: Taking water resilience measurements is optional for research collaborators.*

In this section, we explain how to measure water infiltration.

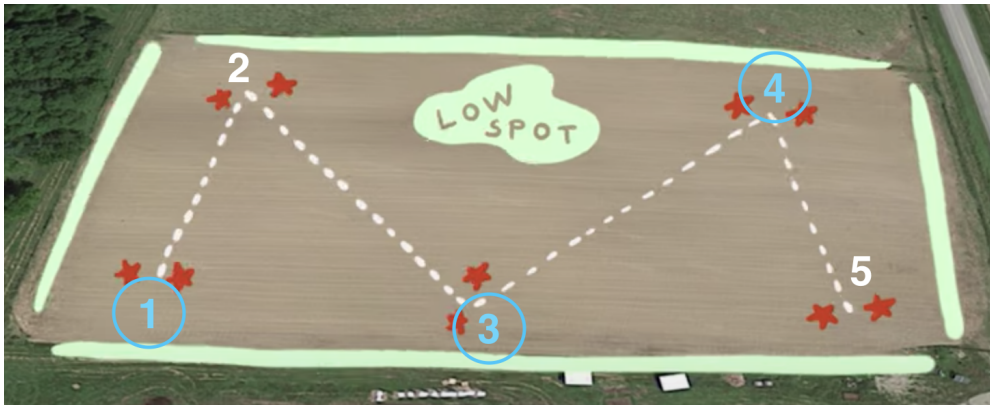
Using a double-infiltration ring to measure water infiltration rate in a field.

How to measure water infiltration

Using a tool called a *double infiltration ring*, we can measure how quickly water infiltrates the soil. Depending on the soil's texture, faster water infiltration indicates that soil has good structure and porosity. It can also indicate that a field has a higher absorption rate during precipitation events, limiting soil erosion. We adapted this protocol from Stroud Water Research Center.

STEP ONE: Plan to take soil samples and infiltration measurements on the same day or within a few days of each other.

- It's best to take water infiltration measurements at field capacity, when excess water in the soil has drained away. Plan to perform all of these activities 2-3 days after a significant rainfall event (≥ 1 in. rain).
- If the soil is too wet, pores in the soil may be blocked with water, and additional water won't be able to soak in when taking infiltration measurements. Alternatively, if the soil is too dry, surface crusting may prevent an accurate measurement of infiltration.
- Do not perform a water infiltration test within a week of a tractor cultivation or tillage event. *Please note on your data sheet when the most recent cultivation or tillage event occurred.*
- We strongly suggest taking soil samples *before* performing an infiltration test, following the instructions starting on page 9.
- When soil sampling, *mark your paired soil sampling locations with a flag or other easily noticeable object.* Water infiltration will be measured *at the 1st, 3rd, and 4th paired soil sampling locations* (see map below). Marking these spots will make it easier to remember where they are located.
- If water infiltration was performed previously on your farm by a Pasa staff member, please aim for the same general infiltration locations as noted on your farm's research field map. You will also be taking paired soil samples at these three locations.



- **For fields in vegetable production *during infiltration measurements:*** Plan to measure infiltration within the cropped bed at 2 of the chosen 3 locations. Measure infiltration within the pathway/walkway at 1 of the chosen 3 locations.

STEP TWO: On your water infiltration sampling day, follow the steps below to take infiltration measurements in the designated research field.

You may need approximately two hours to take infiltration measurements.

1. **Collect the following supplies:**
    - Double infiltration rings
    - Data sheets
    - Ruler (with cm)
    - Easily portable water vessel (should hold at least 1 gallon, like a plastic bucket or small jug)
    - Large water vessel to refill pourable vessel (should hold at least 5 gallons, like a water jug or cooler)
    - Rubber mallet or 3 pound hand sledge
    - Wood block (4x4 in and approximately 15-18 in long works best)
    - Stopwatch (or timer)
    - Scissors or shears (if you are sampling a pasture or cover-cropped field)
    - Torpedo level
    - Sponge or plastic wrap

2. **At the first soil sampling location, choose a spot about 5 ft from where sampling took place to perform the infiltration test.** This should be a spot that was not disturbed by soil sampling, either by walking on the soil or digging for the sample.

    - Make sure this location is relatively similar in plant cover to the soil sampling location. For example, don't choose a bare spot if the soil sampling location was covered with grass.

    - If you can avoid uneven terrain, like extreme dips or troughs in the soil, this will help prevent water from leaking out of the infiltration rings. Also avoid any obvious wheel traffic areas.

    - Clear your chosen spot of weeds or residue. If you are sampling a pasture, hay field, or cover-cropped field, trimming the vegetation close to the surface with a pair of scissors or shears will make it easier to install the equipment and perform the test.

3. **Install the infiltration ring halfway into the ground, approximately 2 in.** Avoid excessive disturbance of the soil during this process.

    a. First, push and turn into the ground as deep as possible.

    b. When more force is needed, place the wood block parallel with the handle and use a mallet/hand sledge to hammer the infiltration ring further into the ground. Try to strike in the middle of the ring to avoid a rocking motion, which can create gaps between the soil and infiltration ring. Avoid striking the metal bar across the top of the infiltration ring; it will bend over time if impacted too often.

    c. Make sure the infiltration ring is level with itself, not parallel to the ground. If needed, use the torpedo level.

    d. With medium pressure, use your fingers to seal the soil against the walls of the infiltration ring to eliminate preferential flow down the walls of the ring.

4. **Add water to determine the timed interval.**

    - First, place a sponge or plastic wrap on the soil surface of the inner ring so that the surface is not impacted while adding water for the first time. Add approximately 1 in of water to the inner ring. Remove the sponge or plastic wrap. Proceed to fill the outer ring.

    - Observe the inner ring for about 20 to 30 sec to see how quickly the first inch of water infiltrates. If it infiltrates quickly, consider using a measurement interval of 3-5 minutes. If it infiltrates slowly, then consider using a longer measurement

interval of 10-15 minutes. Use your best judgment to determine the appropriate interval. If the soil has been recently tilled, you will likely be using short intervals.

- During this step, remove any sizable floating debris.

5. **Add water for determined timed intervals.**

   - Add water to the inner ring to fill to the top (Figure 1). It's alright if water overflows into the outer ring.

Figure 1

www.turf-tec.com

   - If water is overflowing into the outer ring, wait until the water infiltrates so there is no longer water overflowing to the outer ring *before* you start your timer (Figure 2).

Figure 2

www.turf-tec.com

6. ***When there is no longer water overflowing into the outer ring,*** **start the timer for desired time intervals based on the results of step 4.**

    - **IMPORTANT:** *Make sure the outer ring has water in it at all times during the timed interval.* It is not necessary for it to be completely full, but it does need to have some water to prevent the lateral movement of water in the soil from the inner ring to the outer ring.

7. **After the timed interval is over, measure the change in the water level in the inner ring.** Place your ruler in the inner ring and measure from the point where the water level is highest to the top of the inner ring (Figure 3). Record this measurement in centimeters, to the nearest millimeter, on the data sheet provided by Pasa.

Figure 3

Stroud Water Research Center

8. **Repeat steps 5-7 at the same measurement interval until infiltration rates stabilize.**

    - Stabilization occurs when you get the same (± 2-3 mm) measurement 3 times in a row. This could mean that you are taking 5 or more timed intervals.

    - Be sure to be consistent in the location within the inner ring when measurements are taken.

    - *Do not remove the rings until you have finished recording all three measurements.*

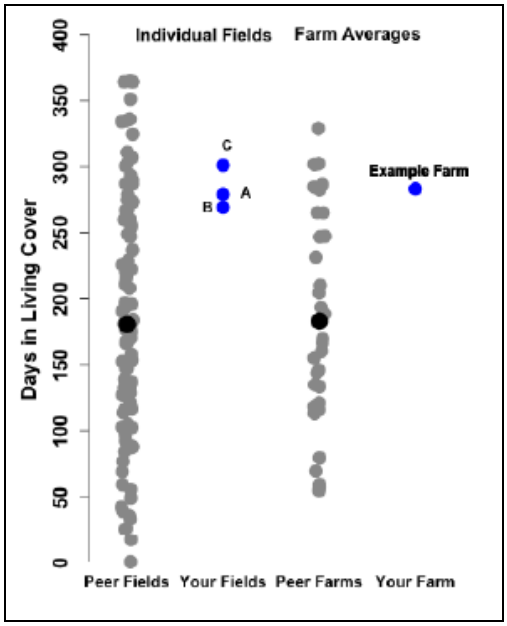
9. **Remove the infiltration rings and fill in the hole.** *Repeat steps 2-8 at the 3rd and 4th paired sampling locations in your farm's designated field.*

Sharing data & knowledge

Custom soil health benchmark reports

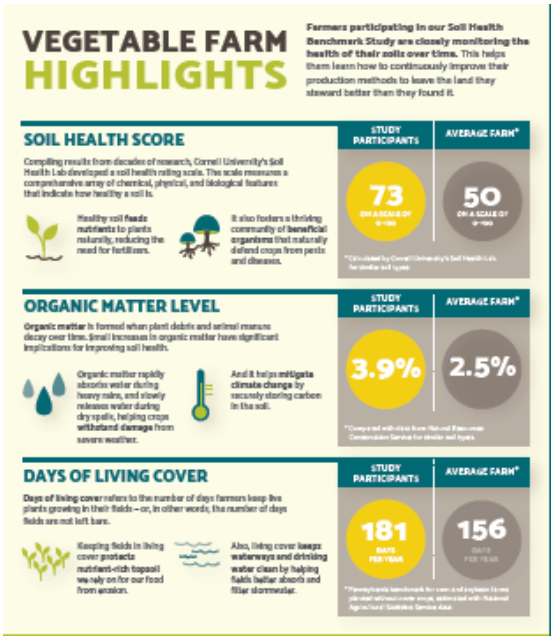
We compile and analyze the data that we collect to create a custom soil health benchmark report for each research collaborator every year they participate in our project. In your report, you'll find your farm's Cornell soil test results along with your soil health management indicators analyzed by Pasa. You'll also see how your results compare with other members of your cohort. We additionally report on trends over time, and trends between farming systems. These reports provide insights about whether your soil health management practices are achieving your intended results, or if there's room for improvement.

In the sample figure to the right, we show the individual, aggregated, and median values for the "days in living cover" indicator by fields and by farm. Find a full sample report at pasafarming.org/sample-soil-report.



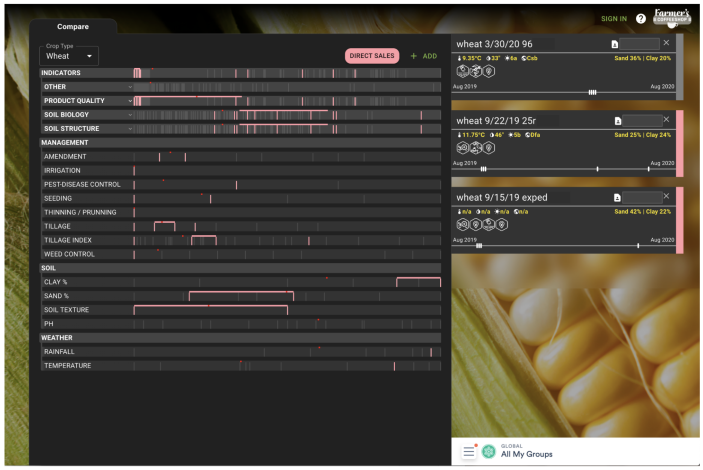
Custom infographic

To help you communicate the importance of your soil health management practices to customers and other important stakeholders, we also create a custom soil health infographic for each research collaborator that highlights your farm's results. Your custom infographic provides the "hard numbers" behind your soil health management efforts in a publicly accessible format—share it far and wide!



Digital tools

Introducing a new opportunity for peer to peer learning between research collaborators through the Farmers Coffeeshop, an exciting, in-depth, digital benchmarking tool. Research collaborators will be able to anonymously compare their soil health metrics and field management practices with fellow farmers in the study and connect with each other on findings, adding a new pathway to collaboratively build soil health.



Workshops & events

Collaborating with peer farmers to further analyze soil health trends and develop practical solutions for tackling the soil health challenges you're experiencing on your farm is one of the most valuable aspects of participating in our Soil Health Benchmark Study.

We offer year-round educational workshops and networking opportunities to research collaborators and other farmers interested in soil health so they can collaboratively review their farm's benchmark reports and work to improve soil health practices.

Appendix A

Example field management record tables

Below are examples of record tables for each farm cohort within our study: vegetable, row crop and grain, and pastured livestock and grazing dairies.

Vegetable farm record table examples

A. Soil disturbance and equipment activity

Farm	Field ID	Field Area (Acres)	Date	Implement [1]	Tillage Depth (in)	Speed (MPH)	Area Covered [2]	Area Covered Unit [3]
Your Farm	F2	1	3.21.22	Disk Harrow	4-6	8	100	% of field
Your Farm	F2	1	6.1.22	Edwards Shovel Inter-row Cultivator	2	4-5	50	% of field
Your Farm	F2	1	6.15.22	Hand cultivation, in row	1	N/A	400	Bed feet
Your Farm	F2	1	10.18.22	Disk Harrow	4	8	100	% of field
Your Farm	F2	1	10.21.22	Grain Drill	1	5	100	% of field
Your Farm	F3	3	4.5.22	Disk Harrow	4-6	8	100	% of field
Your Farm	F3	3	4.15.22	Woods RT60.30 Rototiller	3	4-5	100	% of field
Your Farm	F3	3	5.1.22	Plastic Layer	3	3	50	% of field

B. Planting and termination dates

Farm	Field ID	Field Area (Acres)	Planting Date [4]	Crop [5]	Area Planted [6]	Area Planted Unit [7]	Bed Width (ft)	Termination Date [8]
Your Farm	F2	1	10.1.21	Clover	100	% of field	n/a	3.21.22
Your Farm	F2	1	4.14.22	Kale	1200	bed feet	4 ft.	10.18.22
Your Farm	F2	1	5.12.22	Broccoli	800	bed feet	4 ft.	10.18.22
Your Farm	F2	1	10.21.22	Winter Rye/Vetch	100	% of field	n/a	Spring 2023
Your Farm	F3	3	4.22.22	Oats/Clover	50	% of field	3 ft interrows	Spring 2023
Your Farm	F3	3	5.25.22	Tomatoes	50	% of field	3 ft.	10.1.22
Your Farm	F3	3	10.21.22	Winter Rye/Vetch	50	% of field	n/a	Spring 2023

C. Soil and fertilizer amendments

Farm	Field ID	Field Area (Acres)	Date	Product [9]	Brand	Area Covered [10]	Area Covered Unit [11]	Bed Wdth (ft)	Quantity [12]	Qty Unit [13]	% moisture content [14]	% total N (as is) [14]	% total P (as is) [14]
Your Farm	F2	1	3.30.22	poultry manure		100	% of field	n/a	3	tons	26	2	2.5
Your Farm	F2	1	5.21.22	5-5-3	Fertrell	2,000	bed feet	4	110	lbs			
Your Farm	F3	3	5.15.22	5-5-3	Fertrell	6000	bed feet	4	500	lbs			
Your Farm	F3	3	7.1.22	fish emulsion by drip irrigation	Neptune's Harvest	1500	bed feet	4	5	gal			

Vegetable farm record table notes

[1] If available, please provide more details about machinery used, including the model and make, or email a picture to sarah@pasafarming.org.

[2] For soil disturbance and equipment activity, report the total field area covered with an implement. For instance, if you pass over a third of the research field with an inter-row cultivator, report “33%.” (Do not attempt to estimate the actual area disturbed by the cultivator shanks vs. the undisturbed space between shanks.) If you make multiple passes, record each individual pass as a separate soil disturbance event.

[3] Use this column to record the unit for the Area Covered in the previous column. Units of Area Covered can be in bed ft, row ft, square ft, acres, percentage of the field, or other units that are convenient for your record keeping. Acres or percentage of the field are the preferred units. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[4] For direct seeded events, list seeding date; for transplanted events, list transplant date. Exact dates are important, except if the date is from a previous calendar year, in which case your best estimate is acceptable.

[5] Please include the species for any cover crop mixes or if applicable, the commercial brand name of the mix.

[6] For each planting event, report the total area seeded or transplanted. For example, if beets are planted over a third of the field, record 33%.

[7] Use this column to record the unit for the Area Planted in the previous column. Units of Area Planted can be in bed ft, row ft, sq ft, acres, percentage of the field, or other units that are convenient for your record keeping. For cover crops, acres or percentage of the field are the preferred units. For cash crops, like vegetables, bed ft are the preferred units. For instance, if you are reporting 100 bed ft as the Area Planted, enter "bed ft" here. Please also estimate the bed width for each crop.

[8] Termination dates may coincide with a tillage event or an estimated date of winterkill. Exact dates are important, except if the date will be in a future calendar year, in which case your best estimate is acceptable.

[9] Please provide the detailed product name and if available, please send us analysis results for any manure or compost products applied on your fields. For any compost product, please list the main ingredients.

[10] For soil amendments, report the total area covered with amendment application equipment. For instance, if a manure spreader is used to apply manure to a third of a field, report 33%. If a mineral concentrate is applied by hand to 1,200 bed ft of tomatoes, report 1,200 bed ft.

[11] Use this column to record the unit for the Area Covered in the previous column. Units of Area Covered can be in bed ft, row ft, square ft, Acres, percentage of the field, or other units that are convenient for your record keeping. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[12] It is preferable to report the total quantity applied of each amendment (e.g. tons or pounds). You can also report the rate (e.g. tons/ac). If you are applying liquid, please report the quantity prior to any dilution.

[13] Use this column to record the unit for the Quantity in the previous column. For instance, if you are reporting 1.5 tons, enter "tons" here.

[14] Use this section to record key information from analysis results for any manure or compost products, if available.

Row crop and grain farm record table examples

A. Soil disturbance and equipment activity

Farm	Field ID	Field Area (Acres)	Date	Implement [1]	Tillage Depth (in)	Speed (MPH)	Area Covered [2]	Area Covered Unit [3]
Your Farm	F1	12	3.10.22	Manure Spreader	N/A	6	100	% of field
Your Farm	F1	12	5.17.22	Tank Sprayer	N/A	6	100	% of field
Your Farm	F1	12	5.17.22	John Deere 7000 30" Planter	1	1-3	100	% of field
Your Farm	F1	12	10.25.22	Combine	N/A	1-3	100	% of field
Your Farm	F1	12	11.23.22	John Deere 3800 Grain Drill	1	4	100	% of field
Your Farm	F2	22	5.28.22	Haybine	N/A	4	100	% of field
Your Farm	F2	22	5.28.22	Rake	N/A	6	100	% of field
Your Farm	F2	22	5.28.22	Baler	N/A	6	100	% of field
Your Farm	F2	22	6.04.22	Lime Spreader	N/A	1-3	100	% of field

B. Planting and termination dates

Farm	Field ID	Field Area (acres)	Planting Date[4]	Crop[5]	Area Planted [6]	Area Planted Unit [7]	Termination Date[8]	Seeding Rate[9]	Seed Variety or Name[10]	Seed Price[11]	Yield
Your Farm	F1	12	10.15.21	Winter Rye	100	% of field	5.17.22	60 lbs/ac		$25/50 lbs	
Your Farm	F1	12	10.15.21	Vetch	100	% of field	5.17.22	25 lbs/ac	AU Merit	$114/50 lbs	

Your Farm	F1	12	5.17.22	Corn	100	% of field	10.25.22	30K/ac	KF 52C20	$185/80K sds	180 bu/ac
Your Farm	F1	12	11.23.22	annual ryegrass, triticale	100	% of field	Spring 2021	100 lbs/ac	King's Triticale Plus	$39/50 lbs	
Your Farm	F2	22	Previous Year	Alfalfa	100	% of field	Fall 2021	22 lbs/ac	Kingfisher 101	$189/50 lbs	4 tons/ac

C. Soil and fertilizer amendments

Farm	Field ID	Field Area (acres)	Date	Product Name[12]	Brand	Area Covered [13]	Area Covered Unit[14]	Quantity [15]	Quantity Unit[16]	% moisture content [17]	% total N (as is) [17]	% total P (as is) [17]
Your Farm	F1	12	3.10.22	Dairy Manure		100	% of field	40	tons	58	0.3	0.2
Your Farm	F1	12	5.21.22	28-0-0 UAN		100	% of field	1400	lbs			
Your Farm	F2	22	6.04.22	AG-Dolomite Lime	Bakers	100	% of field	12	tons			

D. Pesticide records

Farm	Field ID	Field Area (acres)	Date	Brand and Product Name [18]	Area Covered [13]	Area Covered Unit[14]	Quantity of Product [19]	Quantity Unit[20]
Your Farm	F1	12	6/30/22	RoundUp Power Max 3	100	% of field	20	fl oz/ac
Your Farm	F2	22	8/1/22	Entrust	100	% of field	22	oz

Row crop and grain farm record table notes

[1] If available, please provide more details about machinery used, including the model and make, or email a picture to sarah@pasafarming.org.

[2] For soil disturbance and equipment activity, report the total area covered with an implement. For instance, if you pass over a third of the research field with an inter-row cultivator, report "33%." (Do not attempt to estimate the actual area disturbed by the cultivator shanks vs. the undisturbed space between shanks.) If you make multiple passes, record each individual pass as a separate soil disturbance event.

[3] Use this column to record the unit for the Area Covered in the previous column. Units of Area Covered can be in bed ft, row ft, square ft, acres, percentage of the field, or other units that are convenient for your record

keeping. Acres or percentage of the field are the preferred units. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[4] Exact planting and termination dates are important, except if the date is from a different calendar year, in which case your best estimate is acceptable.

[5] **Please note:** *For cover crop mixes, please include all species if the cover crop mix is a personal blend, and please list each species in a separate row so we can capture the appropriate rates and prices. If it's a commercial mix, please include the commercial brand name.*

[6] For each planting event, report the total area seeded with a crop or cover crop. For instance, if corn is planted on half a field, report 50%.

[7] Use this column to record the unit for the Area Planted in the previous column. Units of Area Planted can be in bed ft, row ft, sq ft, acres, percentage of the field, or other units that are convenient for your record keeping. Acres or percentage of the field are preferred. For instance, if you are reporting 50% as the Area Planted, enter "% of field" here.

[8] Termination dates may coincide with a tillage event, herbicide application, harvest date, or an estimated date of winterkill. Exact dates are important, except if the date will be in a future calendar year, in which case your best estimate is acceptable.

[9] Lbs/acre or seed population/acre are the preferred seeding rates.

[10] List the variety or name of the seed in this column, if available.

[11] Use this column to list the dollar price of the seed. These units should match the seeding rate units. Price per pound or price per seed count are the preferred units. If you are using the price per bag, please list the quantity of the bag. For instance, enter ($)/50 lbs or ($)/80K sds.

[12] Please provide the detailed product name and if available, please send us analysis results for any manure or compost products applied on your fields. For any compost product, please list the main ingredients.

[13] Report the total area covered with application equipment. For instance, if a manure spreader is used to apply manure to a third of a field, report 33%.

[14] Use this column to record the unit for the Area Covered in the previous column. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[15] It is preferable to report the total quantity applied of each amendment (e.g. tons or pounds). You can also report the rate (e.g. tons/ac). If you are applying liquid, please report the quantity prior to any dilution.

[16] Use this column to record the unit for the Quantity in the previous column. For instance, if you are reporting 1.5 tons, enter "tons" here.

[17] Use this section to record key information from analysis results for any manure or compost products, if available.

[18] Please provide the detailed brand and product name.

[19] *Please report the quantity prior to any dilution.* It is preferable to record the total quantity applied to the field of each product (e.g. ounces or pounds). You can also report the rate (e.g. oz per acre).

[20] Use this column to record the unit for the Quantity in the previous column. For instance, if you are reporting 20 oz, enter "oz" here.

Pastured livestock farm and grazing dairy record table examples

A. Grazing and pasturing events

Farm	Field ID (Paddock)	Field or Paddock Area (Acres)	Start Date	End Date	Animal Type	Animal Count	Avg Weight (lbs)	Area Covered [1]	Area Covered Unit [2]	# of sub-paddocks or sections [3]
Your Farm	P1	12	4.15.22	4.17.22	Milk Cows	60	1200 lbs	100	% of field	0
Your Farm	P1	12	5.21.22	5.22.22	Milk Cows	60	1200 lbs	100	% of field	0
Your Farm	P1	12	6.23.22	6.25.22	Milk Cows	60	1200 lbs	100	% of field	0
Your Farm	P2	30	4.15.22	7.21.22	Dry Cows	15	1100 lbs	50	% of field	3
Your Farm	P1	12	6.1.22	6.15.22	Broilers	200	4 lbs	25	% of field	7

B. Soil disturbance and equipment activity

Farm	Field ID	Field Area (Acres)	Date	Implement [4]	Tillage Depth (in)	Speed (MPH)	Area Covered [5]	Area Covered Unit [6]
Your Farm	P1	12	8.21.22	Bush Hog BH100 Brush Mower	N/A	4	60	% of field
Your Farm	P1	12	8.30.22	Bush Hog BH100 Brush Mower	N/A	4	40	% of field
Your Farm	F2	22	5.28.22	Haybine	N/A	1-3	100	% of field
Your Farm	F2	22	5.28.22	Rake	N/A	1-5	100	% of field
Your Farm	F2	22	5.28.22	Baler	N/A	6	100	% of field
Your Farm	F2	22	6.04.22	Lime Spreader	N/A	4	100	% of field

C. Planting and termination dates

Farm	Field ID	Field Area (acres)	Planting Date [7]	Crop [8]	Area Planted [9]	Area Planted Unit [6]	Termination Date [10]
Your Farm	F3	18	10.15.21	Winter Rye/Vetch	100	% of field	5.17.22
Your Farm	F3	18	5.17.22	Corn	100	% of field	10.25.22
Your Farm	F3	18	11.23.22	Winter Rye	100	% of field	Spring 2023

Your Farm	F2	22	2.21.22	Frost seed clover hayfield	100	% of field	perennial
Your Farm	P1	12	perennial	Pasture	100	% of field	perennial

D. Soil and fertilizer amendments

Farm	Field ID	Field Area (acres)	Date	Product Name *11*	Brand	Area Covered *12*	Area Covered Unit *13*	Quantity *14*	Quantity Unit *15*	% moisture content *16*	% total N (as is) *16*	% total P (as is) *16*
Your Farm	F2	22	6.04.22	AG-Dolomite Lime	Baker's	100	% of field	12	tons			
Your Farm	F3	18	3.10.22	Dairy Manure		100	% of field	40	tons	58	0.3	0.2
Your Farm	F3	18	5.21.22	28-0-0 UAN		100	% of field	1400	lbs			

Pastured livestock farm and grazing dairy record table notes

[1] For grazing and pasturing events, report the area grazed or pastured for each event. For instance, if cows are allowed to graze the entire area of a large paddock over several days, record 100% for area. However, for animals in smaller, enclosed units, like broilers in an enclosed chicken tractor, record all moves through a field as one pastured event, instead of separating out each move the tractor makes. If you estimate the tractor and broilers passed over a quarter of the field over the entire period, record the area covered as 25%.

[2] Use this column to record the unit for Area Covered in the previous column. For grazing and pasturing events, record the area units in acres or percentage of the field. For instance, if you are reporting 100% as the Area Covered, enter "% of field" here.

[3] For each grazing or pasturing event, please record the number of sub paddocks or sections that you may have set up within the field or paddock to manage animal movement through the area. For instance, if you divide a field or paddock into three separate sections or sub paddocks that your cows moved through between the start date and end date, enter "3" here. If your cows had access to the entire field or paddock area during the entire time period between the start date and end date, enter "0" here.

[4] If available, please provide more details about machinery used, including the model and make, or email a picture to sarah@pasafarming.org.

[5] For soil disturbance and equipment activity, report the total area covered with an implement. For instance, if you pass over a third of the research field with an inter-row cultivator, report “33%.” (Do not attempt to estimate the actual area disturbed by the cultivator shanks vs. the undisturbed space between shanks.) If mowing an entire pasture, simply report 100%. If you make multiple passes, record each individual pass as a separate event.

[6] Use this column to record the unit for Area Covered in the previous column. Units of Area Covered can be in bed ft, row ft, square ft, acres, percentage of the field, or other units that are convenient for your record keeping. Acres or percentage of the field are the preferred units. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[7] Exact planting and termination dates are important, except if the date is from a previous calendar year, in which case your best estimate is acceptable.

[8] Please include the species for any cover crop mixes or if applicable, the commercial brand name of the mix.

[9] For each planting event, report the total area seeded or transplanted. For instance, if clover is seeded in an entire pasture, report 100%.

[10] Termination dates may coincide with a tillage event, herbicide application, harvest date, or an estimated date of winterkill, if applicable. Exact dates are important, except if the date will be in a future calendar year, in which case your best estimate is acceptable.

[11] Please provide the detailed product name and if available, please send us analysis results for any manure or compost products applied on your fields. **You do not need to record manure deposited by grazing or pastured animals;** just manure added to a field from a barn or other storage source. For any compost product, please list the main ingredients.

[12] For soil amendments, report the total area covered with amendment application equipment. For instance, if a manure spreader is used to apply manure to a third of a field, report 33%.

[13] Use this column to record the unit for the Area Covered in the previous column. For instance, if you are reporting 33% as the Area Covered, enter "% of field" here.

[14] It is preferable to report the total quantity applied of each amendment (e.g. tons or pounds). You can also report the rate (e.g. tons/ac). If you are applying liquid, please report the quantity prior to any dilution.

[15] Use this column to record the unit for the Quantity in the previous column. For instance, if you are reporting 1.5 tons, enter "tons" here.

[16] Use this section to record key information from analysis results for any manure or compost products, if available.

Appendix B

Example calculations of soil health management indicators

The following indicators are calculated by Pasa staff using field records submitted by research collaborators.

Tillage Intensity Index

The tillage intensity index uses data from a Natural Resources Conservation Service (NRCS) soil erosion model to assign a soil disturbance score to all field operations that can compact or disturb soil. You can find out more information about NRCS Soil Tillage Intensity Ratings (STIR) here.

To calculate this indicator:

1. Match each field operation name to the most appropriate operation match on the NRCS STIR value table. For context, NRCS assigns a single pass with a moldboard plow a score of 65; a secondary tillage disk pass has a score of 32.5; and a grain drill has a score of 2.4.

Field Operation Name	NRCS Operation Name	NRCS STIR Value
moldboard plow	Plow, moldboard	65
disk	Disc, tandem secondary op.	32.5
disk	Disc, tandem secondary op.	32.5
grain drill	Drill or air seeder single disk openers 7 to 10 in spac.	2.4

2. Weight the scores for each operation based on the area covered for a tillage intensity rating.

Field Operation Name	NRCS Operation Name	NRCS STIR Value	Area Covered	Weighted STIR Value
moldboard plow	Plow, moldboard	65	50%	32.5
disk	Disc, tandem secondary op.	32.5	50%	16.25
disk	Disc, tandem secondary op.	32.5	50%	16.25
grain drill	Drill or air seeder single disk openers 7 to 10 in spac.	2.4	50%	1.2

3. Sum all calculated STIR values over the year for each research field.

Field Operation Name	NRCS Operation Name	NRCS STIR Value	Area Covered	Weighted STIR Value	
moldboard plow	Plow, moldboard	65	50%	32.5	
disk	Disc, tandem secondary op.	32.5	50%	16.25	
disk	Disc, tandem secondary op.	32.5	50%	16.25	
grain drill	Drill or air seeder single disk openers 7 to 10 in spac.	2.4	50%	1.2	
				66.2	**Sum total**

Days of Living Cover

The *days of living cover* score is the number of days per year between crop or cover crop seeding (or transplant) and termination (by equipment or weather).

To calculate this indicator:

1. Convert your planting and termination date for each crop or cover crop into "Julian dates," which are simply the number of days past since January 1 (for instance, June 1 is 153).

Planting Date	Julian Planting Date	Crop	Termination Date	Julian Termination Date
10/18/21	0	wheat	5/20/22	140
5/22/22	142	corn	9/7/22	250

2. For each crop or cover crop, subtract the Julian date for termination date from the corresponding Julian planting date to estimate the days of living cover.

Planting Date	Julian Planting Date	Crop	Termination Date	Julian Termination Date	Days of Living Cover
10/18/21	0	wheat	5/20/22	140	140
5/22/22	142	corn	9/7/22	250	108

3. Calculate a weighted days of living cover score for each crop or cover crop by multiplying the days of living cover times the corresponding area planted.

Planting Date	Julian Planting Date	Crop	Termination Date	Julian Termination Date	Days of Living Cover	Area Planted	Weighted Days of Living Cover
10/18/21	0	wheat	5/20/22	140	140	50%	70
5/22/22	142	corn	9/7/22	250	108	50%	54

4. Sum all calculated weighted days of living cover over the year for each research field.

Planting Date	Julian Planting Date	Crop	Termination Date	Julian Termination Date	Days of Living Cover	Area Planted	Weighted Days of Living Cover	
10/18/21	0	wheat	5/20/22	140	140	50%	70	
5/22/22	142	corn	9/7/22	250	108	50%	54	
							124	**Sum total**

Organic Matter Inputs

The organic input score shows the total organic inputs (composts, manures, and mulches) for each research field, in units of tons per acre. This indicator is reported in dry matter tons and only looks at inputs from “outside” the study field. It doesn’t include manure deposited by animals grazing or biomass generated by crops and cover crops.

To calculate this indicator:

1. Convert the unit of each organic matter input into total tons applied.

Field Area (Acres)	Organic Matter Input	Total Amount Applied	Total Tons Applied
0.75	mushroom soil	16 yd³	4.6
0.75	straw mulch	6000 lbs	3

(mushroom soil is about 575 lbs/yd³)

2. Convert total tons applied into total tons of dry matter applied. Pasa’s reference table of common organic matter inputs includes the percent dry matter of these amendments. You can find the table here.

Field Area (Acres)	Organic Matter Input	Total Amount Applied	Total Tons Applied	% Dry Matter	Total Tons of Dry Matter Applied
0.75	mushroom soil	16 yd³	4.6	31%	1.43

0.75	straw mulch	6000 lbs	3	90%	2.7

3. Sum the total tons of dry matter applied over the year for each research field, then calculate the total tons per acre.

Field Area (Acres)	Organic Matter Input	Total Amount Applied	Total Tons Applied	% Dry Matter	Total Tons of Dry Matter Applied	
0.75	mushroom soil	16 yd³	4.6	31%	1.43	
0.75	straw mulch	6000 lbs	3	90%	2.7	
					4.13	**Sum total in tons**
					3.1	**Total in tons/acre**