



BUL 1128

Soil Health: Improvement Guide

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Introduction

HEALTHY SOILS ARE THE BASIS for productive and profitable agricultural systems. But how do land managers know if their soil is healthy and, if it isn't, how can they improve it? This guide—best used in conjunction with the University of Idaho Extension Bulletin *Soil Health: What Is It and Why Is It Important?* (BUL 1117)—provides a step-by-step framework for land managers to use to improve their soil's health.

What Is Soil Health?

Soil health can be defined in several ways. The first definition comes from the Food and Agriculture Organization of the United Nations, which defines it as the continued capacity of soil to function as a vital living system; to sustain biological productivity; to promote the quality of air and water environments; and to maintain plant, animal, and human health within ecosystem and land-use boundaries. For cropland, the definition can be condensed to the continued capacity of soil to function as a vital living system to sustain healthy crop production.

Another way to define soil health is based on the ecosystem services it provides. Healthy soil provides an anchor for plant roots; provides air, water, and nutrients for plants to grow; serves as a suitable habitat for soil fauna; acts as a living water filter; and supports buildings, roads, and other structures. Under this second definition, keeping the intended function of soil in mind is also important; crop land does not need to support a road to be considered healthy but should be able to anchor plant roots and provide habitat for soil fauna.

An even simpler explanation involves evaluating it by working through a series of questions in a flowchart (Figure 1). Using the chart, producers and land managers can determine their soil's health without incurring the cost of any specialized testing.

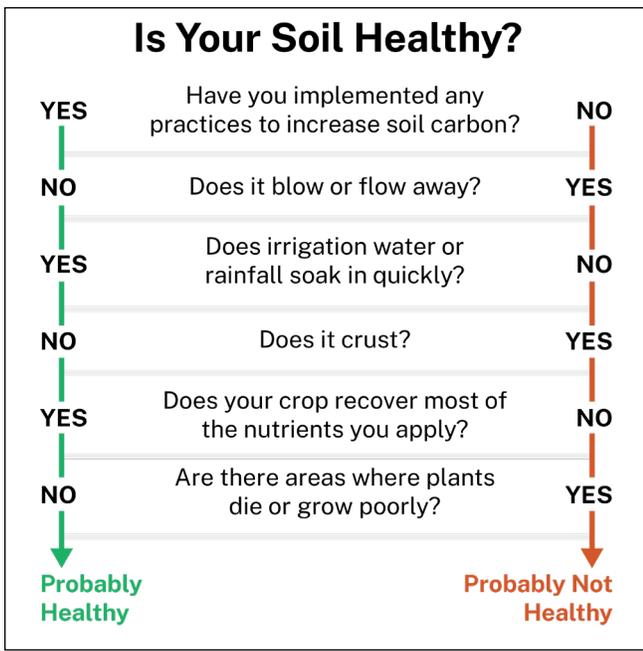


Figure 1. Flowchart to assess soil health in a simplified manner. Adapted from [McGuire 2019](#).

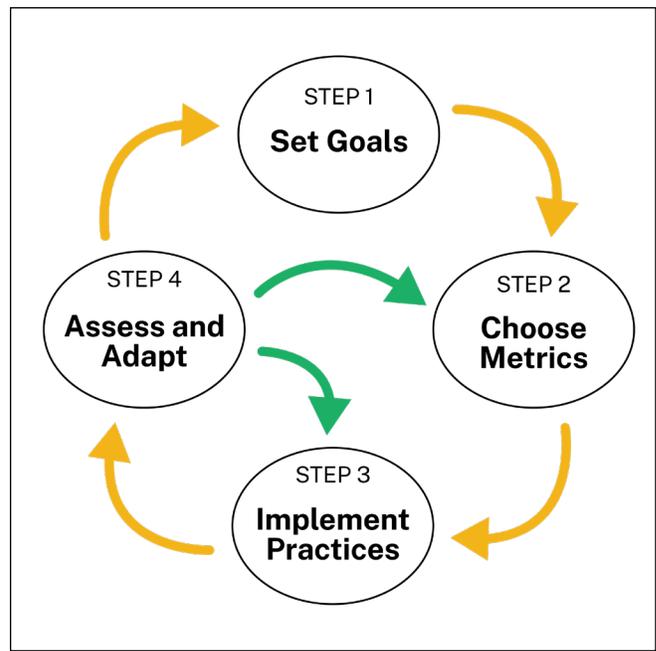


Figure 2. Iterative process for improving soil health intended for all land managers, who can enter at any step.

Assessment Framework

Improving soil health is a multistep and iterative process (Figure 2). Accordingly, our framework is a step-by-step process. However, ours is intended for all land managers, whether they have been implementing soil health practices for a long time or are just starting. Because it is an iterative process, enter at any step.

Step 1: Know Your Goals

Successful land managers begin assessing soil health by asking two questions: What are my goals for improving the health of my soil? and What steps can I take to achieve my goals? Without a goal in mind, land managers set themselves up for failure. Any assessment or metric for measuring progress will not be useful and the results will be disappointing. Some examples of goals include (but are not limited to) the following:

- reduce fertilizer usage
- ensure the continued usage of the soil for future generations
- improve infiltration or water-use efficiency
- provide extra forage for livestock
- improve operation profitability
- reduce wind erosion

Next, personalize your goals to fit your operation. Additionally, although operation-wide goals are valuable, it is beneficial to develop individual field-level ones that address barriers to improve crop production. Land managers can (and are encouraged to) have multiple goals, but prioritize them and measure progress according to each goal.

Step 2: Choose Appropriate Soil Health Metrics

The next step in the process is choosing metrics to assess progress toward the goals established in step 1. Assess the metrics before implementing appropriate practices (step 3) and at appropriate time intervals after implementation to evaluate change over time (step 4). In terms of specific metrics, there are many ways to gauge soil health. The Natural Resources Conservation Service offers guidelines and how-to guides for conducting assessments of some important soil health indicators: <https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/soil-health/soil-health-assessment>.

It is critical to keep in mind your soil health goals when choosing which soil health indicators to monitor. For example, if the goal is to reduce fertilizer inputs, one of the indicators should probably be conducting soil chemical analyses at different times of the growing season and perhaps

petiole or plant samples. This helps land managers calibrate fertilizer applications by identifying if too little or too much fertilizer was applied. If the goal is to increase infiltration or water-use efficiency, chemical samples, although still important for nutrient management, don't indicate much about whether infiltration has increased due to practice implementation. Instead, infiltration tests and perhaps an assessment of soil crusting or compaction are better.

Other critical components for assessing soil health: conducting assessments at the same time(s) of year and maintaining the methods you use—that is, carry them out under similar soil conditions and crop stage too so that you can compare results effectively over time. For example, soil samples taken for chemical analyses before fertilizer application one year and after application during another are not really comparable. Similarly, soil infiltration tests taken before harvest one year and after harvest during another may not be comparable due to compaction from machinery or soil disturbance that occurs during harvest. Also, if you are conducting soil chemical or biological analyses, use the same assessment team—send the samples to the same commercial labs every year to reduce interlab variability.

Step 3: Implement Appropriate Management Practices

Table 1 includes some examples of best management practices to achieve the goals listed in step 1. Note that this list is not exhaustive.

The most successful managers start small and make incremental changes. For example, rather than implementing a practice on their entire operation, it might be best to apply it on either one field or even a part of a field first. Indeed, at a smaller scale it is easier to assess whether or not a practice is having the desired effect and to tweak it if it's not.

It is also less risky if the implemented practice has undesired impacts on a cash crop or overall profitability. Choose a practice that is more easily integrated into an operation's current management system, available equipment, and climate. For example, if labor is sparse and the operation large

Table 1. Examples of best management practices associated with the goals listed under step 1.

Goal	Possible Practices
Reduce fertilizer usage	Add manure or compost Incorporate legumes into crop rotation Increase soil testing (spring, in-season, and fall) Utilize irrigation scheduling and sensors to reduce leaching
Ensure the continued usage of the soil	Cover crops No-tillage or reduced tillage Residue retention Perennial vegetation Rotational grazing
Improve infiltration	Cover crops No-tillage or reduced tillage Perennial vegetation Add manure or compost Residue retention Avoid tillage when soil is wet Controlled traffic
Provide extra forage for livestock	Rotational grazing Cover crop Double cropping Perennial vegetation
Improve operation profitability	Reduce fertilizer inputs No-tillage or reduced tillage to reduce fuel use and equipment hours Utilize of irrigation scheduling and sensors to reduce pumping
Reduce wind erosion	Cover crops Double cropping Perennial vegetation Residue retention

(or there is no “down time” in the spring or fall), incorporating a cover crop might be difficult. Similarly, if an operation is committed to doing tillage, including livestock manure or compost may fit in more easily than an operation that has moved to no-tillage.

Step 4: Assess and Adapt

Assess all steps and adapt them as needed on an ongoing basis. The goals in step 1 will likely change the least over time while the management practices implemented in step 3 will need to be adapted more often. However, goals in step 1 could change as well. For example, if a land manager feels like they

have met their set goals, they will need to choose new goals to work toward. Goals may also change if there is a shift in the crops grown or if a child joins the operation. Regardless, review goals and their prioritization annually to ensure their relevance.

As stated in step 2, retain consistent metrics over time to more easily track your progress. Yet sometimes changing the metrics may be necessary—for instance, if goals change. Too, as time passes, assessing more metrics, as technology and methods become cheaper or more advanced, might be warranted.

Part of step 4 should also include tracking metrics over time to assess progress. It's important to consider that each soil health metric has its own timeline for change. For example, Soil Organic Matter content is a slower-changing one; it might take years or even decades to see a significant difference. Other metrics may show variability from year to year. A simple program, like Microsoft Excel, is an easy and effective way to visualize data and see overall trends. For instance, soil penetration resistance (a measurement to assess compaction) may fluctuate year to year due to differences in weather or crop (e.g., different equipment weights for different crops, number of field operations needed, spring soil moisture). By graphing the data, land managers may be able to see that after practice implementation, the overall trend is decreasing (i.e., decreased compaction). Alternatively, if graphing data shows a stable, unchanging trend (i.e., compaction stays the same) or an undesirable one (i.e., increased compaction), the manager should consider whether to modify the practice or to schedule an assessment at a different time of the year.

Management practices that work on one operation may not work in another—even those that are part of the same operation. Furthermore, there is often not 100% success the first time something new is tried; plus, some metrics are slow to show change. Thus, it is important to adapt. Sometimes the practice implemented as part of step 3 will not work

and is not worth continuing. However, it's worth considering why a practice did not work and whether it would be more successful with some alteration. For example, perhaps a fall-planted cover crop did not germinate. If this was due to an unusually cold fall or that the cover crop could have been planted earlier, it might be worth trying again. But if the cover crop did not germinate because irrigation water was unavailable (and is unlikely to ever be available), then it might be more worthwhile to try another practice that aligns with the goals and fits within the constraints and characteristics of the field.

Conclusion

Land managers should follow the step-by-step framework shown in Figure 2 to improve soil health. By (1) setting soil-health goals, (2) choosing appropriate assessment metrics, (3) implementing suitable practices, and (4) assessing and adapting as needed, soil health can be improved. Personalize soil health goals for each operation and even to individual fields within an operation. Without goals, it is nearly impossible to assess progress toward improving soil health.

Choosing appropriate metrics for assessment is also important, as is assessing chosen metrics at the same time(s) of year when soil conditions and crop stage are the most similar. When choosing soil health practices to implement, choose practices that can easily be integrated into the operation's current management system, available equipment, and climate. The process should be incremental to reduce risk while allowing for ample assessment and adaptation of goals, management practices, and assessment metrics to promote success. Indeed, change takes time and if tillage hasn't fixed your soil problems yet, it probably won't start anytime soon.

Photo Credit

McGuire, A. 2019. "Soil (Health) Evaluation Begins by Asking 'What's the Problem with my Soil?'" Center for Sustaining Agriculture and Natural Resources, Washington State University.

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