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**Natural
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**Soil
Quality
Institute**

Guidelines for Soil Quality Assessment in Conservation Planning

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United States Department of Agriculture
Natural Resources Conservation Service
Soil Quality Institute

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Table of Contents

Note: This **Guide** is organized according to the nine steps of the NRCS planning process to facilitate its use in the development of NRCS conservation plans. In situations that do not call for a full conservation plan, use only those sections that are needed.

OVERVIEW

This document provides suggested guidelines for assessing soil quality in the conservation planning process. It is designed for field personnel of agencies, such as the Natural Resources Conservation Service (NRCS) and Cooperative Extension Service, and other agricultural professionals. People with extensive knowledge of soil quality as well as those who are new to soil quality will find the guide useful.

This guide is modeled on the NRCS Planning Process so that it can be used as a part of conservation planning. However, the information can also be used to conduct informal soil quality assessments or as an educational resource for teaching about soil quality. Although the guide is published by NRCS, it is intended for as wide an audience as possible, and adaptation is strongly encouraged.

A NOTE ON THE NRCS PLANNING PROCESS

This guide complements existing NRCS planning documents, including the Quality Criteria in the Field Office Technical Guide (FOTG, Section III), Resource Management Systems (RMS) discussed in the FOTG and National Planning Procedures Handbook (NPPH), and the Conservation Practices Physical Effects (CPPE) document (FOTG, Section V). It is designed to provide information for a planner to use in assessing and improving soil quality in the planning process. Because the term, " soil quality," is relatively new, this guide was developed to help conservation professionals better understand how to fit soil quality into planning. It does not lessen the importance of the other natural resources recognized in the planning process (water, animals, plants, and air). This guide provides a road map for the planner and is not meant to replace the FOTG and Planning Handbook. All of the nine steps do not have to be followed to complete a successful soil quality evaluation.

Although this guide deals specifically with soil quality assessment and enhancement, it can be tied to the whole planning process, because soil resources affect water, animals, plants, and air.

HOW TO USE THE GUIDE

AS A PLANNING GUIDE: Follow the nine steps of planning in Part II. Follow the steps sequentially when possible. Use the *Soil Quality Assessment Field Record* in **Resources** to record information for the conservation plan.

FOR INFORMAL ASSESSMENTS: Select only the relevant parts. Use the *Soil Quality Assessment Field Record* to record only the information needed. All nine steps of planning do not need to be followed, nor must the steps be followed in sequence.

FOR QUICK ASSESSMENTS: Use the charts in **Resources** to find information for selecting indicators and management solutions.

PART I

INTRODUCTION TO SOIL QUALITY

WHAT IS SOIL QUALITY?

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to:

- sustain plant and animal productivity
- maintain or enhance water and air quality
- support human health and habitation

Soil function describes what the soil does. Soil functions are: (1) *sustaining biological activity, diversity, and productivity;* (2) *regulating and partitioning water and solute flow; (3) filtering and buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposition; (4) storing and cycling nutrients and other elements within the earth's biosphere; and (5) providing support of socioeconomic structures and protection for archeological treasures associated with human habitation.* (Seybold et al, 1998).

For the purposes of this guide, the terms soil quality, soil health, and soil condition are all interchangeable.

Soils vary naturally in their capacity to function; therefore, *quality is specific to each kind of soil.* This concept encompasses two distinct but interconnected parts: inherent quality and dynamic quality.

Characteristics, such as texture, mineralogy, etc., are innate soil properties determined by the factors of soil formation—climate, topography, vegetation, parent material, and time. Collectively, these properties determine the *inherent quality* of a soil. They help compare one soil to another and evaluate soils for specific uses. For example, all else being equal, a loamy soil will have a higher water holding capacity than a sandy soil; thus, the loamy soil has a higher inherent soil quality. This concept is generally referred to as *soil capability.* Map unit descriptions in soil survey reports are based on differences in the inherent properties of soils.

More recently, soil quality has come to refer to the *dynamic quality* of soils, defined as the changing nature of soil properties resulting from human use and management. Some management practices, such as the use of cover crops, increase organic matter and can have a positive effect on soil quality. Other management practices, such as tilling the soil when wet, adversely affect soil quality by increasing compaction.

In this guide, soil quality refers to the dynamic quality of soil—those properties that are affected by management.

What is Soil Quality and Why is it Important?

- Soil quality refers to the dynamic quality of soil—those properties that are affected by management.
- Soil quality evaluation is a tool to assess management-induced changes in the soil and to link existing resource concerns to environmentally sound land management practices.

Soil quality assessments are thus used to evaluate the effects of management on the health of the soil. The guidelines in this booklet provide information for performing the most typical soil quality assessments, which include:

model familiar to farmers will promote faster learning of the approaches outlined in this guide. Joint soil quality assessments between conservationist and producer will facilitate the blending of producer's knowledge and scientific information, thus strengthening the information base, the ability to formulate workable solutions, and the likelihood of adoption of best management practices. (Romig et al, 1995).

KEY CONCEPTS IN SOIL QUALITY ASSESSMENT

Soil Quality Indicators

Soil quality assessments are conducted by evaluating *indicators*. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. Indicators are measured to monitor management induced changes in the soil.

Useful Indicators?

Useful indicators are:

- easy to measure.
- able to measure changes in soil functions.
- assessed in a reasonable amount of time.
- accessible to many users and applicable to field conditions.
- sensitive to variations in climate and management.
- representative of physical, biological or chemical properties of soil.
- assessed by *qualitative* and/or *quantitative* methods.

Soil quality indicators are selected because of their relationship to specific soil properties and soil quality. For example, soil organic matter is a widely used indicator, because it can provide information about a wide range of properties such as soil fertility, soil structure, soil stability, and nutrient retention. Similarly, plant indicators, such as rooting depth, can provide information about the bulk density or compaction of the soil.

Indicators can be assessed by *qualitative* and/or *quantitative* techniques. A qualitative assessment is the determination of the nature of an indicator. A quantitative assessment is the accurate measurement of an indicator. For example, if erosion is the indicator being evaluated, a qualitative assessment would be the observation of rills and gullies in the field, indicating that erosion is occurring. A quantitative assessment would measure the amount of erosion occurring in the field. In another example, a qualitative assessment of infiltration would be the observation of excessive runoff water from a field. A quantitative assessment would measure the infiltration rate.

Qualitative assessments have an element of subjectivity and, thus, are best done by the same person over time to minimize variability in the results.

Indicators measured with a quantitative method have a precise, numeric value. Therefore, different people conducting the same measurement should be able to produce very similar results.

Table 1. Example of a Minimum Data Set of Indicators for Soil Quality

Indicator	Relationship to Soil Health
Soil organic matter (SOM)	Soil fertility, structure, stability, nutrient retention, soil erosion, and available water capacity
PHYSICAL	
Soil structure	Retention and transport of water and nutrients, habitat for microbes, and soil erosion
Depth of soil and rooting	Estimate of crop productivity potential, compaction, and plow pan
Infiltration and bulk density	Water movement, porosity, and workability
Water holding capacity	Water storage and availability
CHEMICAL	
pH	Biological and nutrient availability
Electrical conductivity	Plant growth, microbial activity, and salt tolerance
Extractable nitrogen (N), phosphorus (P), and potassium (K)	Plant available nutrients and potential for N and P loss
BIOLOGICAL	
Microbial biomass carbon (C) and N	Microbial catalytic potential and repository for C and N
Potentially mineralizable N	Soil productivity and N supplying potential
Soil respiration	Microbial activity measure

(Adapted from: Doran et al, 1996; Larson and Pierce, 1994; and Seybold et al, 1997)

PART II

INFORMATION COLLECTION
AND
ANALYSIS
FOR
SOIL QUALITY ASSESSMENT

USING Part III-RESOURCES WITH PART II

Resources follows Part II of the guide and contains information which may be used either independently or in conjunction with the guide. A brief summary of each section of Resources is outlined below.

- The *Soil Quality Checklist* lists a brief summary of all nine steps and a space to check off when each step is completed. This can be used in the field and the office. It is to be used as a guide or roadmap for assessing and improving soil quality.

- The *Soil Quality Assessment Field Record* lists all nine steps of soil quality assessment and provides space to record information collected from the producer, measurement data, and guidance on the information recorded.

- *The Flow Chart for Selecting Indicators* provides a framework for selecting indicators for a minimum data set.

- *Suggested Management Solutions to Soil Quality Problems* can be used either with, or independently of, the guide. This table begins with an indicator or concern, proceeds to possible reasons for the problem, continues with suggested changes in management to improve soil quality, and concludes with respective conservation practices listed in the Field Office Technical Guide.

- *Comparison of Soil Quality Assessment Methods* briefly summarizes the pros and cons of different methods for assessing soil quality. Users who are familiar with the various methods may want to skim over Step 3 and glance at this chart before selecting methods.

- The *NRCS Soil Health Card Template (NRCS Template)* is a generic template for creating a locally adapted *Health Card* for qualitative assessments. More information about the *NRCS Template* is given in Step 3. The *NRCS Template* can be used as is or as a template to develop a card that is specific to a state or region.

3. INVENTORY RESOURCES—ASSESSING SOIL QUALITY

COLLECT BACKGROUND INFORMATION

Visit the farm or ranch and collect information from the producer about current and previous uses of the site. Use the soil survey to provide information about the inherent properties of the soil(s). This information will help integrate the impacts of the inherent properties of the site with past, current, and future management. Use the *Soil Quality Assessment Field Record* or case file to record information.

During the *Site Assessment* (stage 1), collect information about the inherent properties of the site such as precipitation and soil map unit (soil type). While these characteristics cannot be modified, they will significantly affect the types of changes in soil quality that can be expected at a given site.

Discuss *Present/Future Management* (stage 2) to determine whether the farmer is planning practices consistent with improving or maintaining soil quality. For example, if a producer is about to convert a long-standing pasture to a cropping system, consider this change when predicting the effects on soil quality. Understanding management is critical to setting realistic goals for soil quality levels.

Past Management History (stage 3) helps establish the type of management that has been used and whether the current land use has been contributing to degradation of soil quality. For example, eroding hillsides that have been planted to continuous corn could have very poor soil quality. Adding a crop rotation with forages or grasses or planting an annual winter cover crop could help improve soil quality.

Gather information about various aspects of the operation, such as irrigation practices; types and rates of fertilizer, amendment, and manure applications; tillage systems, such as reduced or no-till; and tillage operations, including ripping and subsoiling. A general history covering the previous five to 10 years is optimal.

Gathering Producer Knowledge (stage 4) will allow producers to provide any other information or observations about the property that has not yet been discussed. Often, producers do not categorize information in the same way as specialists do. Therefore, it is useful to continue the discussion to allow producers to provide information which could be significant later in the assessment. For example, the farmer might point out annually occurring wet spots in the field, areas with low yields, or areas of salt accumulation. Such information helps determine effective methods for sampling.

This discussion also provides an opportunity to discuss any problems that the farmer has observed at other times of the year such as erosion, heavy crusting, or stunted growth. Open ended questions, such as, "What else can you tell me about the property that you think is significant for soil quality?" or "What

"Sampling" guidelines in the **Notes on Sampling Section** at the end of Step 3 provide additional suggestions to enhance consistency of results.

Local soil health cards are "do-it-yourself" farmer tools and are **not** meant to be used as an official document in a conservation plan. Health cards can be used to conduct assessments with producers, and information gleaned from health card assessments should be used to discuss soil quality. Producers should be encouraged to utilize the information gathered with the card. However, the card and results should be left with the producer. Only if the producer agrees can a summary of the health card results be included in the conservation plan.

NRCS Soil Health Card Template (NRCS Template)

If qualitative soil quality assessment information is desired for an NRCS conservation plan, adapt for local use the *NRCS Template* that comes with this guide. Although technically this template can be used as is, the indicators and rankings it uses have been collated from various parts of the United States and are very general.

When adapting the template, select only locally relevant indicators and descriptive terms, and be sure to add others that are needed for local soil and agricultural systems. Generally, no more than 10 indicators should be used on a template, as too many questions make the process cumbersome.

As with the farmer-developed health cards, assessments should be done by the same person over time, under similar conditions, and during the same time of year for each sampling.

Suggested guidelines for sampling times are included with the NRCS Template. Check carefully that this information is locally relevant, and modify any suggestions which are not appropriate to local conditions.

Soil Quality Test Kit

The Soil Quality Test Kit, developed by the ARS, is an on-farm soil quality assessment tool. It was modified and enhanced by the NRCS Soil Quality Institute with NRCS field staff. The kit is used as a screening tool to give a general direction or trend of soil quality; e.g., whether current management systems are maintaining, enhancing, or degrading the soils. It can also be used to troubleshoot problem areas in the field.

Included in the kit are tools to measure standard soil quality indicators such as respiration, water infiltration, bulk density, electrical conductivity, pH, aggregate stability, slaking, and earthworms.

The kit is accompanied by the Soil Quality Test Kit Guide, which provides a list of supplies and instructions for the tests as well as background and interpretive information for evaluating the results from each test. The Instructions Section describes the procedures for 12 soil quality diagnostic tests and includes worksheets for gathering data. The guide also lists sources of supplies needed to build a field test kit.

The kit provides a soil quality assessment method that quickly provides quantitative, reliable data. Most of the also test for elements, such as aluminum and boron, which may be considered yield limiting in high levels. Most labs can also test for soil organic matter, total organic carbon, and total soil nitrogen. Some will also conduct physical tests such as bulk density, water release curves, and soil water content.

Laboratories differ in their procedures for some tests. Try to use the same lab, or be aware of any differences in methodology. Use in-state labs when possible, since they are familiar with local and regional soils. Request information about the methodology and units used by the lab, so that lab results may be compared with results from the Test Kit. In some cases, lab or Test Kit values will have to be converted to accurately compare results from the two methods.

Some specialized labs do very specific tests for biological properties, including microbial respiration and activity or direct counts of bacteria, fungi, protozoa, and nematodes. A few also identify arthropods and soil fauna. In locations with a university or research station nearby, it may be possible to take advantage of specialized equipment such as cone index penetrometers for measuring soil strength or neutron probes for measuring soil water.

Sampling requirements are similar to those described for the Soil Quality Test Kit. Generally, local labs have specific instructions on the number of samples needed and on sample preparation. Samples for biological analysis generally must be refrigerated (not frozen) and shipped within 24 hours.

Choosing a Method

The most important criteria in selecting which method, or parts of a method to use, is that the results are practical and consistent with the information needs of the producer.

Before proceeding with the soil quality evaluation, talk with the producer about the type of information desired. (See the ***Flow Chart** for Selecting Indicators* and *Suggested Management Solutions to Soil Quality Problems* in **Resources.**) Often, he or she will have some idea of the desired approach to the evaluation process.

For example:

- Some producers may want as much information as possible, in which case a full set of indicators could be used.
- Others might identify only one or two very specific problems, such as erosion and water infiltration. In this case, a whole data set does not need to be used; only those specific indicators can be assessed.
- Some producers may only want numerical results from an accredited soil testing laboratory.
- Other producers may want to collect the information themselves and use a tool such as the soil health card or kit.

It is important to clarify this information before beginning the evaluation process so that unnecessary or irrelevant data is not collected.

4. ANALYZE RESOURCE DATA—EVALUATING AND INTEGRATING RESULTS

LOOK FOR PATTERNS

Group test results from similar indicators and look for patterns. For example, does one field consistently have poor infiltration and drainage? Does another field show a large quantity of soil life, and have good residue decomposition and a desired smell? Do the crops in another field show a healthy stand, good vertical roots, and consistent color? Each set of results may show an emerging trend in a particular field toward some level of soil quality.

COMPARE RESULTS

If different methods have been used, an ideal set of results would show indicators with similar trends. For example, the Soil Health Card would show excellent tilth in the same field that had higher organic matter percent values reported from the lab tests. Or, both the Soil Quality Test Kit and lab tests would show higher bulk density in a field which the Health Card has shown to have an obvious hard pan or stunted roots. Again, these results suggest a trend toward a particular level of soil quality.

EVALUATE DISCREPANCIES

Interpretation of results is more complicated if similar indicators show differing trends from similar measurements or from different methodologies. For example, a visual observation might indicate stunted and horizontal roots, but the Soil Quality Test Kit may show that water infiltration and bulk density are adequate. In this scenario, consider all the possible reasons for the root problems such as pathogen infestation, nutrient deficiency, or element toxicity (aluminum). In particular, if plants are part of the assessment, be sure to look beyond soil characteristics to possibilities such as disease or nutrient problems.

The Soil Quality Test Kit Guide is a good source for background information and interpretation of results. For each indicator in the kit, the guide has an interpretation section with information for evaluating results and improving soil quality. Although the Soil Quality Test Kit Guide is written to support the indicators in the Soil Quality Test Kit, the interpretation section is useful for results from either the health cards or NRCS Template, since the indicators are often the same.

Interpretive information from soil testing labs is not very comprehensive, but the labs do usually send useful target ranges and recommendations for certain fertility and chemical measurements.

When a discrepancy occurs, carefully review the sampling procedure and analysis. Be sure to check that all samples were collected at the same time and under similar conditions such as location, moisture, and pre- or post-tillage. Ensure that procedures were followed very carefully for the test kit and lab analysis. For example, if lab samples for bulk density were collected from within the crop row and test kit samples were collected from between the crop rows or in the wheel track, the same "sites" were not sampled and would not be expected to be similar. Be sure that any numerical results have been

5. FORMULATE ALTERNATIVES—IMPLEMENTING STEPS TO IMPROVE SOIL QUALITY

Formulate alternatives to help meet the goals of the producer, solve natural resource problems, and take advantage of opportunities to improve or protect resource conditions.

Before implementing specific solutions, integrate the inherent properties and capabilities of the system with the results of the soil quality evaluation and the features of the management system. This ensures that solutions are viable and practical. For example, producers in very hot and dry climates will have more difficulty building and maintaining organic matter than producers in cooler and moist climates. In this case, it is important to recognize the limits of the system and consider the most effective approach.

Because soil quality and natural resource management are site specific, it is impossible to list every scenario and solution for typical problems. *Suggested Management Solutions to Soil Quality Problems*, in **Resources**, includes brief solutions; however, be sure to supplement these with local and regional solutions.

The NRCS Field Office Technical Guide is an excellent source of information with its complete list of relevant conservation practices, such as crop rotation, cover crops, irrigation water management, and tillage, adapted for each region. Personnel from NRCS, Cooperative Extension Service, and Conservation Districts as well as Certified Crop Advisors and private consultants are often very knowledgeable about the impacts of management decisions on production and on soil resources. They can provide helpful, complementary information as solutions are formulated.

The Soil Quality Thunderbook provides NRCS field offices a convenient place to file soil quality information such as Soil Quality Institute products and regional information about useful alternatives for improving soil quality.

Involve farmers in the discussion about results and formulating solutions. Often, when farmers are presented with information about their soils, which they know can have an impact on profitability, they will be motivated to seek solutions from their peers and from other resources as well. Talking with other farmers, they will often develop their own solutions, which they are more likely to implement than a strategy presented to them without their input.

6. EVALUATE ALTERNATIVES

Consider any possible positive or detrimental side effects of each alternative. Include ecological, natural resource, social, cultural, and economic impacts as well as the size of farm, type of operation, resource availability, and farming systems in any proposed ideas. Help evaluate alternatives and predict consequences of various practices and operations. Give special attention to any ecological values protected by law or executive order.

PART III

RESOURCES

Soil Quality Assessment Checklist

Instructions: Photocopy this page and use it during soil quality assessments as a brief checklist or reminder for all steps. Check off DONE box when a step is completed.

STEP	SUMMARY	DONE
1. Identify Problems and Opportunities	Contact farmer. Identify general resource problems, opportunities, and concerns. Collect information on general needs of farmer. Consult Conservation District long-range plans, soil maps, other resources.	
2. Determine Objectives: Assessing Soil Quality Goals	Define producer's objectives for soil quality. Identify whether producer wants to improve or maintain soil quality or to troubleshoot problem or low productivity areas.	
3. Inventory Resources: Assessing Soil Quality	Collect background information. Determine which methods/indicators best meet the needs of the producer. Do soil quality assessment. Record data.	
4. Analyze Resource Data: Evaluating and Integrating Results	Look for patterns and trends in results. Compare results from different methods. Evaluate discrepancies carefully. Re-evaluate soil quality if necessary. Provide general summary of soil quality assessment to producer.	
5. Formulate Alternatives: Implementing Steps to Improve Soil Quality	Formulate alternatives to meet the farmer's goals, address natural resource problems, and improve or protect resource conditions. Integrate inherent properties and capabilities of system with results of soil quality evaluation and features of the cropping systems. Use *Suggested Management Solutions to Soil Quality Problems* in **Resources**, Soil Quality Test Kit Guide, interpretive information from soil testing labs, Soil Quality Thunderbook, NRCS Field Office Technical Guide, personnel from Cooperative Extension Service, Conservation Districts, Certified Crop Advisors, and private consultants for ideas. Involve producers in discussions about results and formulating solutions.	
6. Evaluate Alternatives	Consider side effects of alternatives, including ecological, natural resource, social, cultural, and economic impacts; size of farm; type of operation; and resource availability. Predict consequences of various practices and operations. Give special attention to any ecological values protected by law or executive order.	
7. Make Decisions	Help producer with final decision. Work together to sketch out a timeline for implementation. Prepare necessary documentation.	
8. Implement the Plan	Provide technical assistance. Apply relevant practices in the conservation plan. Supply technical support. Be available during the process of implementation. Include all collected information in the conservation plan.	
9. Evaluate the Plan: Following Up	Make plans for follow-up evaluations and visits.	

Soil Quality Assessment Field Record-cont.

Stage 3. Past Management History (5-10 yr. Optimal)	
Cropping System (Rotations, fallow history, etc.)	
Fertilizers/Pesticides (N inputs, pesticide use, etc.)	
Tillage/Residue Cover (Past tillage, frequency and type)	
Irrigation (Past irrigation, type, amount, how long)	
Unusual Events (Floods, fires, land-leveling)	
Stage 4. Additional Farmer Knowledge	
Other Information (Wet spots, salt accumulation, etc.)	

3. Inventory Resources—Assess Soil Quality (II)

	Evaluating Soil Quality	
Indicator Evaluated	**Method(s) Used**	**Preliminary Results**

Note: Detailed results should be kept on forms from method used

(See NOTE at end of Chart)

Soil Quality Assessment Field Record-cont.

4. Analysis of Resource Data—Evaluating and Integrating Results

Major Trends

Physical:	Biological:	Chemical:

Inconsistencies Observed Across Tests:

Possible Explanations and Solutions:

5. Formulating Alternatives: Improving Soil Quality

Key Problems	Proposed Solutions

6. Evaluate Alternatives

Proposed Solutions	Ecological/Social/Economic Impacts

Flow Chart for Selecting Indicators

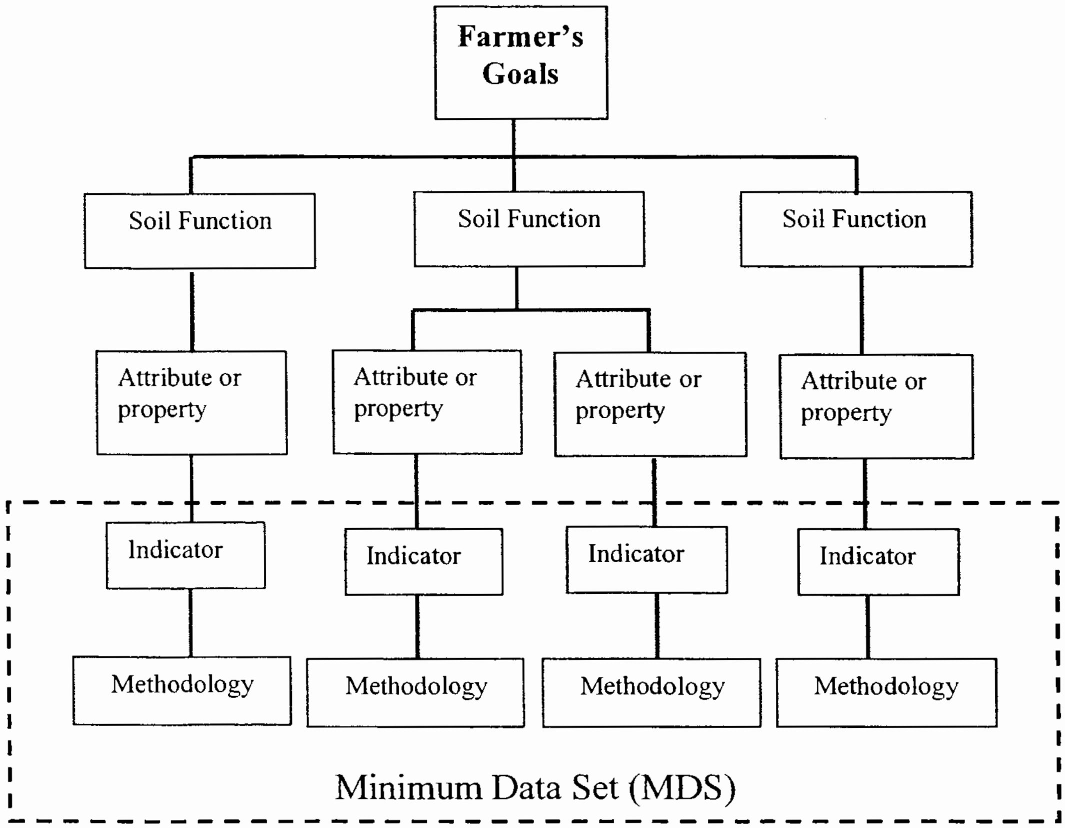

Figure 1. Soil quality framework outlining the process for selecting indicators for an MDS to assess soil quality.

The farmer's goals for soil quality are established, and soil functions supporting those goals are identified. Soil functions are what the soil does or the services it provides. For each soil function, measurable soil properties that influence the capacity of the soil to perform that function are defined. The attribute or property reflects the measured change in the function. One or more attributes or properties can describe the change in a specific soil function. The attribute or property can be difficult to measure directly, so an indicator can be used to serve as an indirect and practical measure. The choice of the indicator would be based on the available methodology, including ease of measurement and accuracy needed. The methodology could be either qualitative or quantitative, depending on what is needed to fulfill the soil quality goals of the farmer. The minimum data set (MDS) is the minimum number of indicators that will provide a practical assessment of the soil functions identified.

For example, a goal of the farmer may be to improve infiltration of rainfall. A soil function relating to this goal would be partitioning rainfall at the soil surface. A soil property that can measure change in this soil function would be infiltration. An indicator of this property could be infiltration rate. A methodology for this indicator could be the single ring method used in the Soil Quality Test Kit. This is a quantitative method. An alternative methodology could be observations of ponding or runoff during a rainfall. This would be a qualitative method.

Problem/Indicators	Possible Reason for Low Ranking	Suggestions to Improve Soil Quality	Possible NRCS FOTG Practices*
Problem: Soil life Indicators to test: Earthworms Soil respiration Microbial biomass Pitfall trapping	Low organic matter Low residues Excess pesticides or fertilizers Excess tillage Poor aeration	Increase organic residues Use conservation tillage Use crop rotations Add cover crops	Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340)
Problem: Salinity Indicators to test: Electrical conductivity Observe white crust	Saline seeps Saline irrigation water/well Shallow water table Poor drainage Excess evaporation	Leach excess salts Plant deep rooted crops Grow salt tolerant crops Increase vegetative cover Manage irrigation water Improve drainage	Irrigation water management (449) Conservation crop rotation (328) Soil salinity management-nonirrigated (571) Subsurface drain (606) Surface drainage-field ditch (607) Surface drain-main or lateral (608)
Problem: Erosion Indicators to test: Observe rills, gullies Topsoil depth Aggregate stability	Lack of cover and residue Low organic matter Poor aggregation Tillage pan or compacted layer Tillage practices that move soil down slope Excessive tillage Intensive crop rotation	Diversify crop rotations Reduce tillage Use animal manure Use cover crops Increase surface residue or roughness Shorten slope length Plant strip crops Use wind breaks	Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340) Contour farming (330) Strip-cropping, contour (585) Terrace (600) Grassed waterway (412) Contoured buffer strips (332)
Problem: Infiltration Indicators to test: Infiltration rate Aggregate stability Soil structure	Compaction Surface crusting Plow pan Poor soil structure/aggregation Excess sodium	Add organic residue Add animal manure Use cover crops Diversify crop rotation For sodium problem, apply gypsum and flush with irrigation water Subsoil or rip when soil is not excessively wet or dry Use tillage that preserves soil structure	Chiseling and subsoiling (324) Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340) Contour farming (330) Strip-cropping, contour (585) Terrace (600) Irrigation water management (449)
Problem: Organic matter/ residue Indicators to test: Organic carbon Percent residues	Excess tillage Residue burned off Low residue crops Too much fallow Insufficient additions of crop residue	Diversify or increase crop rotations Add animal manure Use cover crops Use high residue crops Reduce tillage	Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340)
Problem Soil pH	Use of ammonium fertilizers No liming Poor drainage	Soil test - correct pH levels Add lime for low pH Improve drainage	Nutrient management (590)

Comparison of Soil Quality Assessment Methods

Assessment Tool	Speed of Use/Results	Ease of Use	Comprehensive Data Set	Cost	Farmer Interaction with advisor	Advantages	Disadvantages
Soil Health Card	Use: Fast (15-30 min.) Results: Immediate	Easy	Usually	None	Low to high	Landowners can use independently and are more involved, results easy to interpret, locally adapted.	Reliability of information, requires specific conditions for sampling, subjectivity in interpretation of results
NRCS Soil Health Card Template	Use: Fast (15-30 min.) Results: Immediate	Easy	Yes	None	High	Results easy to interpret, locally adapted, can be included in conservation plan	Reliability of information, requires specific conditions for sampling, subjectivity in interpretation of results
Soil Quality Test Kit	Use: Moderate (4-6 hours for comprehensive evaluation) Results: Immediate	Intermediate -hard	Yes	Low to moderate	High	Reliable information, data can be collected by various users, interpretation of tests available in guide	Some tests difficult to interpret, not locally adapted, requires specific conditions for sampling, labor intensive
Lab Analysis	Use: Fast (15-30 min.) Results: 2-3 weeks	Easy	No-Physical and biological indicators require specialty analysis	Moderate to Expensive; variable	Low	High reliability and precision, professional recommendations accompany results for some tests.	Need help to interpret, need outside lab, all tests not available, potential high costs for repeated tests

INDICATOR	RANKING			SCORING		
	Low	Medium	High	Circle one		
Porosity	Few worm and root channels	Weak plow pan, some new and old root and worm channels	Many worm and root channels, many pores between aggregates	L	M	H
Crusting	Soil surface seals easily, seed emergence inhibited	Some surface sealing	Soil surface has open or porous surface all season	L	M	H
Water Infiltration	Water on surface for long period of time after rain or irrigation	Water drains slowly after rain or irrigation, some ponding	No ponding after heavy rain or irrigation, water moves steadily through soil	L	M	H
Drainage	Excessive wet spots in field, ponding, root disease	Some wet spots in field and profile, some root disease	Water is evenly drained through field and soil profile, no evidence of root disease	L	M	H
Water Holding Capacity	Plant stress immediately following rain or irrigation, soil has limited capacity to hold water, soil requires frequent irrigation	Crops are not first to suffer in area from dry spell, soil requires average irrigation	Soil holds water well for long time, deep topsoil for water storage, crops do well in dry spells, soil requires less than average irrigation	L	M	H
Wind or Water Erosion	Obvious soil deposition, large gullies joined, obvious soil drifting	Some deposition, few gullies, some colored runoff, some evidence of soil drifting	No visible soil movement, no gullies, clear or no runoff, no obvious soil drifting	L	M	H
Crop Vigor/Appearance	Stunted growth, uneven stand, discoloration, low yields	Some uneven or stunted growth, slight discoloration, signs of stress	Healthy, vigorous, and uniform stand	L	M	H

INDICATORS	BEST TIME FOR ASSESSMENTS OF INDICATORS		
	Stage of Crop Growth	Moisture Conditions	Tillage
Earthworms	Pre-plant, active growth	Good soil moisture	Before
Soil Organisms	Pre-plant, active growth	Good soil moisture	Before
Smell	Anytime	Adequate soil moisture	Anytime
Organic Material	Pre-plant, active growth	NA	After
Residue Decomposition	Anytime	Adequate soil moisture	NA
Compaction	Anytime	Adequate soil moisture	Anytime
Workability	Pre-plant, post harvest	Adequate soil moisture	During tillage
Soil Tilth/Structure	Pre-plant, active growth	Adequate soil moisture	Anytime
Soil Aggregates	Pre-plant, active growth	Adequate soil moisture	Not too soon prior to or after tillage
Porosity	Pre-plant, active growth	Adequate soil moisture	Not too soon prior to or after tillage
Crusting	Pre-plant, active growth	Adequate soil moisture	Anytime
Water Infiltration	Anytime	After irrigation or rain	Not too soon prior to or after tillage
Drainage	Anytime	After irrigation or rain	Anytime
Water Holding Capacity	Pre-plant, active growth	After irrigation or rain	Anytime
Wind or Water Erosion	Anytime	Any	Anytime
Crop Vigor/Appearance	Active growth	Adequate soil moisture	NA
Plant Roots	Active growth	Adequate soil moisture	NA
Root Mass	Active growth	Adequate soil moisture	NA
Salts	Any	Any	Any
Sodium	Any	Any	Any

NOTE: This calendar is approximate. Tailor it to local climates, cropping systems, and soil types.

Appendix A—Example of A Farmer Developed Soil Health Card

Maryland Soil Quality Assessment Book

About the Book

This soil quality assessment book is a locally adapted field tool designed by the University of Maryland in collaboration with the USDA-NRCS Soil Quality Institute and 17 Maryland farmers. It was developed to help users evaluate changes in soil quality as affected by field management. Regular use will allow you to record long term changes in soil quality among different fields and various farming systems. The book is designed for farmers, but can also be used by agricultural support professionals such as soil conservationists, soil scientists, Cooperative Extension agents, and agriculture industry representatives.

How to Use the Book

Tools Required

- A shovel and a wire flag.

Soil Quality Assessment

- Select a field for evaluation and record the field and/or farm ID on an ***Assessment Sheet***. Use the ***Field Notes/Inputs Sheet*** to enter any other significant information such as inputs, crops, weather, soil moisture or field conditions.

- Turn over a shovelful of soil about six-eight inches deep. On the ***Assessment Sheet*** rate each indicator by marking an X or shading out to the box that best represents the value for that indicator. If you need more specific guidelines refer to the ***Indicator Table*** for information on how to rate each indicator, and to the ***Assessment Guide*** for the best time to do evaluations.

Notes

- Assessments are most effective when filled out by the same user over time and under similar moisture levels.

- Assessments are qualitative, therefore evaluation scores do not represent any absolute measure.

- Assessing in more than one spot per field will provide more accurate results.

Assessment Guide

Indicator	Best assessed
Earthworms	Spring/Fall Good soil moisture
Organic Matter Color	Moist soil
Organic Matter Roots/Residue	Anytime
Subsurface Compaction	Best pre-tillage or post harvest Good soil moisture
Soil Tilth/Mellowness/ Friability	Good soil moisture
Erosion	After heavy rainfall
Water Holding Capacity	After rainfall During growing season
Drainage Infiltration	After rainfall
Crop Condition	Growing season Good soil moisture
pH	Anytime, but at same time of year each time
Nutrient Holding Capacity	Over a five year period, always at same time of year.

Field Notes/Inputs

Farm I.D. ________________

Field I.D. ________________ Date ____________

Crop ________________ Acres ____________

Inputs

	Type	*Quanitity*	*Price*
Fertilizer			
Lime			
Manure			
Cover Crops			
Pesticides			
Other			
Equipment Used			

Problems, Comments, Weather Conditions

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Yields

Amount ________________________

Units ________________________

Moisture ________________________

Price ________________________