United States
Department of
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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:

- Comparing the effects of different management systems on soil quality between two or more fields with similar soil map units (soil types).
- Monitoring trends in one or more fields over time to determine the impact of management on soil quality and to identify soil resource problems.
- Diagnosing causes of problem areas.

The soil quality assessment procedures outlined in this guide should not be used to compare soil quality among different soil map units (soil types).

THE SIGNIFICANCE OF SOIL QUALITY

History

The NRCS, Agricultural Research Service (ARS), Cooperative Extension Service, and others have been working toward improving soil quality for many years by encouraging best management practices such as erosion control and nutrient management. As soil quality has emerged as a leading concept in natural resource conservation and protection, stronger emphasis is now being placed on the relationship between specific dynamic soil properties and soil performance. Enhancement of these dynamic soil properties is the goal of soil quality management.

Multiple Benefits and Applications

Conservation measures utilized by farmers, agricultural professionals, and public and private agencies are already tightly linked to soil quality management. Conservation practices, such as conservation tillage, buffers, nutrient and pest management, range and pastureland management, and wetland and stream bank restoration incorporate soil management goals and treatments. Achievement of water quality, air quality, and carbon sequestration goals rely on improving soil quality. For example, one typical method for improving soil quality by increasing organic matter involves reducing tillage, a fundamental practice for reducing erosion. Decreasing erosion improves water quality by reducing sediment runoff. In areas subject to wind erosion, conservation tillage reduces the amount of particulate matter in the air. Thus, reducing tillage to improve soil quality also benefits erosion control, air quality, and water quality goals.

Integrated Approach

Soil quality is a useful model to evaluate and improve the soil resource as it provides an integrated method for assessing multiple aspects of the soil and their connections. By linking biological, physical, and chemical properties of soil, all of the components and interactions of a soil system are viewed together. This integrated approach leads to more comprehensive solutions as compared to assessing each soil property independently.

Familiarity Promotes Learning and Acceptance

Soil quality management is a useful and effective approach to resource conservation and best management strategies. Producers are already familiar with many soil building practices and many producers already use the approach of integrated soil management when evaluating the effects of their practices on soil health. A 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.

Qualitative assessments usually can be done simply and quickly, and producers can complete them unassisted. If tools are required, they are usually simple and easily obtained. However, because of the subjective nature of the qualitative assessment, results can not be compared to any "target" levels for soil properties, nor should results be compared among different users or different farms.

Although more time consuming and sometimes more complex, quantitative assessments are more appropriate to use when different people will be conducting the assessment over time or when there is interest in comparing soils to some target level based on soil surveys or other data.

Minimum Data Sets and Indicators

Since it is impractical to measure every ecosystem or soil property, many researchers have proposed a minimum data set, which is the smallest set of soil properties or indicators needed to measure or characterize soil quality. Identifying key soil properties or attributes that are sensitive to change in soil functions establish a minimum data set. Table 1 is an example of a minimum data set, which shows the relationship of each indicator to soil health concerns.

A minimum data set does not usually encompass all relevant properties for a region or farming system. It is an example of a *minimum* set of indicators required to obtain a comprehensive understanding of the soil evaluated.

Each minimum data set is tailored to a particular region or soil map unit (soil type) and includes only those properties relevant to the soil types, farming system, and land uses of the areas being evaluated. For example, a minimum data set for the Northeast United States would probably not include such indicators as salt accumulation and electrical conductivity, while a data set for areas with arid and semi-arid soils would include these indicators.

Compiling a minimum data set helps to identify locally relevant indicators and to evaluate the link between indicators selected and significant soil and plant properties for the region.

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.

The Nine Steps of Planning

1. IDENTIFY PROBLEMS AND OPPORTUNITIES

Make contact with the producer. Identify general resource problems, opportunities, and concerns, and collect information about the producer's general goals. Take advantage of long-range plans prepared by Conservation Districts to review local concerns and to access local information, such as soil maps, or other resources related to the producer's goals or problems.

2. DETERMINE OBJECTIVES—ASSESSING SOIL QUALITY GOALS

Define the producer's objectives for soil quality. Since different producers will have different goals for a soil quality evaluation, ask them to clearly state what they hope to achieve.

Some producers may be seeking assistance to improve overall soil quality, because they recognize the direct impact this will have on the profitability and health of the operation. Other producers may have recognized soil quality degradation in specific fields and request assistance only in those fields. Some may require assistance in troubleshooting small problem areas.

Generally, their goals will fall into one of the following areas:

- Improve soil quality.
- Maintain soil quality.
- Stop or reverse soil quality degradation.
- Troubleshoot problem areas.

Results of comparisons of different management systems in different fields or in problem areas can often be obtained quickly. A few sets of measurements from each field or area can often provide important insight into the direct effects of management.

Results of evaluations of new practices or information about long-term trends will not be available immediately. Explain to the producer that the first set of results provides baseline values that are specific to that farming system. Subsequent evaluations later in the season and in following years will be necessary to reach definite conclusions about the trends and levels of soil quality.

Comparing results with "established" or "target" levels, as determined by a soil survey, can be done, but it requires caution. If this is the producer's goal, be sure to use quantitative measurements (See Step 3), and read Step 4 for more information about this type of evaluation.

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 other concerns or problems have you experienced with regard to soil quality?", will often provide information not obtained in stages 1 through 3.

METHODS OF SOIL QUALITY ASSESSMENT

A variety of methods or approaches are currently used to measure and assess soil quality. The methods discussed in this guide range from primarily qualitative to purely quantitative. They are as follows:

- Soil Health Card
- NRCS Soil Health Card Template (NRCS Template)
- Soil Quality Test Kit
- Laboratory analysis

These methods provide important information about soil quality, whether the goal is to determine changes in soil health over time or to compare management effects on soil quality in different fields or pastures. Various combinations of these methodologies may be used. No single one is inherently better or more effective.

Soil Health Cards

The soil health, or soil quality, assessment card is a qualitative tool designed by and for farmers. The cards contain farmer-selected soil quality indicators and associated ranking descriptions typical of local producers. Generally, indicators listed, such as soil tilth, abundance of earthworms, or water infiltration, can be assessed without the aid of technical or laboratory equipment.

All cards have a scoring system, which usually includes either a range of poor to good or a numerical scale from 1 to 10 for each indicator. Individual indicator scores are generally not combined or totaled, and there is usually space on each page to record results for each field.

Cards are obtained from the local NRCS, Conservation District, or Cooperative Extension Service office in those states that have produced cards. They can also be accessed at the Soil Quality Institute Web site at http://soils.usda.gov/sqi. This site also has information on how to conduct farmer meetings to produce a local soil health card. **Appendix A** lists key features of the Maryland Soil Health Card.

Health cards integrate physical, biological, and chemical properties in ways that are familiar to producers. For example, the cards use terms like tilth, which refers to the physical structure of soil and which also depends on biological properties. Soil health cards are producer friendly, quick, and require only basic tools such as a shovel and wire flag. Results are obtained immediately, allowing the user to evaluate numerous fields quickly. Directions for use are found on each card.

To use the card, simply pick an area that is representative of the field. Qualitatively score each of the indicators using your best judgement. Record the information with other important data, including management practices, fertilizer rates, pest management, manure application, etc. Soil quality changes are best interpreted by having the same person assess the field under approximately the same conditions (time of the year).

"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 tests can be conducted in the field and/or in the office.

Some users have found that completing a whole set of measurements in the Soil Quality Test Kit may take as long as four to six hours. Thus, it may be unrealistic to expect a farmer to use the kit independently. However, the results can be determined immediately after conducting the tests. Be sure to allow time to assist with, or do, many of the measurements. Also, a few of the morphology estimations are considered difficult for the untrained professional to perform, so be prepared to have a soil scientist or specialist help with this part of the analysis. The kit can be used by people with little experience. To reduce error, first-time users should practice with people who have more experience.

Guidelines for the number of samples and detailed steps for data collection and processing are listed in the Kit guide and should be followed carefully. Although sampling should be conducted in similar spots and at similar times of year, it does not have to be conducted by the same person each time since the measurements are quantitative.

NOTE: The Soil Quality Assessment Field Record in **Resources** provides space to record all of the same information as the Site Description Data Worksheet included with the Soil Quality Test Kit Guide. Those who perform the nine-step evaluation and who use the Soil Quality Test Kit Guide will thus find that they do not need to fill out the Site Description Data Worksheet if they use the Soil Quality Assessment Field Record from this guide. However, users of the kit will need to fill out the Soil Quality Data Worksheets included with the Soil Quality Test Kit Guide for processing data.

The Soil Quality Test Kit Guide explains how to put the kit together and is available from NRCS state offices and the NRCS Soil Quality Institute. It can be downloaded from the Soil Quality Institute Web site at http://soils.usda.gov/sqi.

Laboratory Analysis

Soil testing laboratories throughout the U.S. have tests for many soil properties that are useful for soil quality evaluation. While some of these tests can also be done with the Soil Quality Test Kit, farmers may not have the time to run the tests, or they may prefer to obtain their results from an accredited laboratory.

Although the sampling time (field portion) is shorter when using a soil testing lab, getting results may take from three days to two weeks. Health Card and Kit results can be determined on the same day that sampling occurs. The biggest advantage of a lab analysis is assurance that the results are obtained with quality control and that they are numerically reliable for long-term comparisons. Also, results from fertility related tests are often returned with interpretations and with specific recommendations to help make management decisions.

The most standard tests performed by soil testing labs are for chemical properties and for micronutrients and macronutrients. Chemical tests include pH, EC, cation exchange capacity, nitrate, and ammonium. Macronutrients and micronutrients include sulfate, phosphorus, potassium, calcium, magnesium, zinc, and copper. Labs can 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.

Selecting a Soil Quality Assessment Approach

- Select those methods and indicators that will match the information needs of the farmer and provide practical information.
- Be sure that the person conducting the evaluation (farmer and/or specialist) has the resources to successfully complete the method.
- Check that the method can be repeated with ease over time.
- Ensure a realistic time frame for completion of the assessment.

The Comparison of Soil Quality Assessment Methods chart in **Resources** summarizes the pros and cons of the various approaches.

Notes on Sampling

General guidelines on soil sampling for soil quality include:

- Collect samples from areas that have similar soil map units (soil types) if making comparisons.
- Sample at approximately the same time of year, from year to year, and under similar soil moisture conditions.
- Take samples or make observations from representative areas of the field. Avoid non-representative areas such as those that are uncharacteristically wet or dry, extremely hilly, or eroded. Also avoid field borders, fertilizer bands, and spots close to a road.
- If the objective is to evaluate a specific problem, collect samples from specific "problem areas" and, for comparison, from nearby "normal areas" within the same soil map unit (soil type).
- Sample consistently. For example, only compare samples from the crop row (vs inter-row) and/or from the wheel track (vs non-wheel track). When comparing two fields, compare a row sample to a row sample and an inter-row to an inter-row.
- Collect samples under similar moisture conditions. Soil moisture dramatically influences all biological properties and some physical properties.
- Try to take replicate samples to obtain more reliable results. A replicate sample is defined as two or more samples taken and analyzed from a similar area and intended to represent the same management/field or area of study. Three or four replicate samples will give more reliable results.

Notes on Record Keeping

Sample location, date, and depth should be recorded for every set of samples or observations to ensure long-term consistency in sampling. When possible, mark on the Soil Quality Assessment Field Record map precise details of where samples were collected. Where available, a photocopy enlargement of the soil survey of the field or a printout from a digital soil survey with a digital orthophotographic background is ideal for this purpose.

The Soil Quality Assessment Field Record provides space to record information collected during a soil quality assessment, whether a formal conservation plan is being developed or an informal assessment is being conducted.

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 accurately converted, if necessary. If results seem too divergent, conduct specific tests again to verify results.

Look carefully at trends which are similar but are affected by different management practices or climatic effects and which result in observations or measurements that seem inconsistent. For example, a field may have high organic matter, excellent tilth, and good workability but also low microbial counts and few signs of soil life. This discrepancy could result from having sampled when conditions were drier or cooler than normal, or it could be due to recent fertilizer and pesticide applications. Soil also tends to have large inherent spatial variability even within the same soil map unit (soil type), which can confound effects. When contradictory trends emerge, talk in detail with the producer about these observations. Often he or she will have knowledge about the soils or management practices to help resolve the apparent discrepancies.

BASELINE AND TARGET VALUES

A basic goal of a soil quality assessment is to provide information about the trend of soil quality (increasing, decreasing, or maintaining).

Results obtained from the first soil quality assessment provide the baseline from which to evaluate future changes. Subsequent measurements provide information about the trend or direction of soil properties. The goal is indicators moving in the desired direction or becoming relatively stable at an acceptable level.

Achieving a target level may be desired. Soil survey tables list soil texture, EC, clay content, available water holding capacity, pH, and surface organic matter. Hence, if a producer has made similar measurements using quantitative methods, values can be compared.

While it is theoretically possible to compare soil quality assessment results with established values for soil properties, these values must be realistic, achievable, and carefully tailored to each farmer’s system, soil map unit (soil type), and land use. It is important to remember that some soils are inherently better than others, and comparisons are mainly valid among similar soil map units (soil types). Use caution when comparing results, as some soils simply have much better inherent properties than others. Soil quality will seem much higher in these soils irregardless of management attempts to overcome differences.

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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.

7. MAKE DECISIONS

By now, the producer should have sufficient information to select practices to implement. Help with the decision, but be sure that the producer knows that the primary choices and final decision belong to him or her. After the major changes or practices have been selected, work together to sketch out a timeline for implementation. Prepare necessary documentation at this stage.

8. IMPLEMENT THE PLAN

Help the producer by providing technical assistance in applying any relevant practices in the conservation plan. Be available throughout the process of implementation.

9. EVALUATE THE PLAN—FOLLOWING UP

Because improvement of soil quality can take many years, followup and evaluation are critical. A commitment to monitoring the effects of management changes as they relate to attaining soil quality goals helps to demonstrate progress and may also reveal the need for modifications in the management plan. In most cases soil properties will not begin to show improvement for a number of years, so sampling should be continued to verify that the desired property is either at the same level or is improving.

Followup is also necessary to verify that results collected the first year were not overly influenced by some short-term impact. For example, baseline values for compaction may have been higher than normal, because the farmer pulled heavy equipment across the field during a very wet spring. Followup and evaluation are also needed to ensure that the recommendations for best management practices are not having a negative effect and for some reason causing a decline in soil quality.

Because the goals of soil quality are to sustain productivity, enhance water and air quality, and support human health and habitation, conservation plans developed during this process are long-term and open-ended. Over time, plans can be modified to reflect changes in economics, land use, and technology. Continual evaluation and followup is highly recommended to help ensure that the plan remains appropriate and continues to lead toward a successful outcome.

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

Instructions: Photocopy form for use in the field to record relevant information during soil quality assessment.

General Information			Date:
Map Location	State:	County:	
Geographic Location	Longitude:	Latitude:	
Field or Site Location:		Field Name/ID:	
Landowner:	Address:	Phone:	

1. Identify Problems and Opportunities:	
Problems:	General Goals:

2. Objectives—Assess Soil Quality Goals:
Specific Goals:

3. Inventory Resources—Assess Soil Quality (I)		
Background Information		
Stage 1. Site Assessment		
Soil Series:	Soil Type (Surface texture):	
Erosion:	Slope:	Other:
Mean Annual Precipitation:	Mean Annual Temperature:	
Stage 2. Present Management		
Cropping System (Rotations, crops, cover crops)		
Fertilizers/Pesticides (N inputs, pesticide use, etc.)		
Tillage/Residue Cover (Type, depth, frequency, timing, % cover, etc.)		
Irrigation (pivot, gravity, furrow, amount and timing, etc.)		
Recent Changes (removal/addition to CRP, rotation, crop type)		
Other		

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.

Aerial view of field showing sampling sites and location of environmentally sensitive areas, such as ponds, creeks, wetlands, and other fragile sites adjacent to the field.

Scale: 1 Inch = _____________ft (NA indicates not to scale)

Instructions: Show major landmarks, environmentally sensitive areas, etc. Mark approximate sites sampled. Mark problem areas with poor yields, suspected problems.

Field Map and Sampling Record

Additional Information and Sampling Notes:			
# of Samples	Sample Depth	Sample Date	Row/Wheel Track
Other Significant Information (weather, yields, pest infestations, etc.)			

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

Soil Quality Assessment Field Record-cont.

7. Make Decisions	
Practices Selected to Improve Soil Quality	Timeline for implementation
8. Implement the Plan	
Technical Information Provided:	Additional Support:
9. Evaluating the Plan—Followup Plans and Activities	
Plans for followup (timeline, field visits, etc.):	

(**NOTE:** The *Soil Quality Assessment Field Record* does not contain space for recording data or observations about particular soil quality indicators. This information should be recorded on either the Soil Quality Health Card, the NRCS Soil Health Card Template, or the data worksheet included in the Soil Quality Test Kit Guide. For example, if indicators are being measured using tools in the Soil Quality Test Kit, data notes should be kept on the Soil Quality Data Worksheets included with the Kit).

Flow Chart for Selecting Indicators

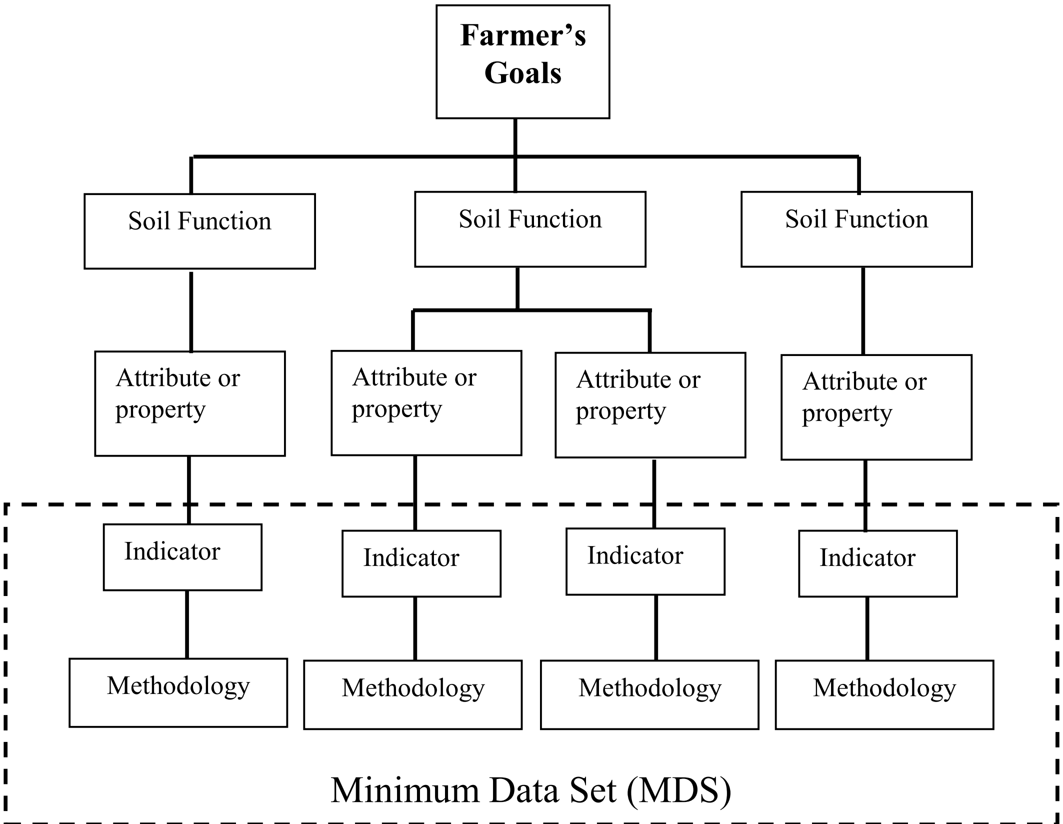

Figure 1. Soil quality framework outlining the process for selecting indicators for an MDS to assess soil quality.

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.

Suggested Management Solutions to Soil Quality Problems

Instructions: Use this table to determine possible causes of the soil quality problem, possible indicators to test for the problem, and potential management solutions. This is not a comprehensive list.

Problem/Indicators	Possible Reason for Low Ranking	Suggestions to Improve Soil Quality	Possible NRCS FOTG Practices*
Problem: Compaction Indicators to test: Bulk density Penetration resistance Porosity Root growth patterns	Working wet soil Excess traffic Heavy machinery Repeated tillage at same depth Excess animal traffic Poor aggregation Low organic matter	Avoid working wet soil Reduce traffic/tillage operations Use controlled traffic patterns Avoid using heavy machinery Subsoil or rip when soil is not excessively wet or dry Alter tillage depth Add organic residues Diversify cropping system Use conservation tillage Add cover crops Use crop rotations Add animal manures Use non-compacting tillage (e.g., chisel vs moldboard)	Residue management, no-till and strip till (329 A) Residue management, mulch till (329 B) Residue management, ridge till (329 C) Residue management, seasonal (329 D) Chiseling and subsoiling (324) Conservation crop rotation (328) Cover and green manure crop (340)
Problem: Crop disease Indicators to test: Plant health Crop vigor Yield	Compacted layers Saturated soil Soil pathogen problems Nutrient deficiencies or unbalance Low organic matter Monoculture Low biological diversity	Soil test - correct nutrient and pH levels Check for pathogens/pests Reduce compaction following harvest Improve drainage Increase organic residue Use animal manure Add cover crops Use crop rotation Diversify cropping system	Nutrient management (590) Pest management (595) Conservation crop rotation (328)
Problem: Crusting Indicators to test: Aggregate stability Slake test Observations	Excess sodium Low organic matter Low residues	Increase organic residues Reduce tillage depth Use animal manure Add cover crops For sodium problem - apply gypsum and flush with irrigation water	Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340)

Problem: Drainage Indicators to test: Infiltration rate Hydraulic conduct.	Tillage pan High water table Poor soil structure	Subsoil to break up tillage pan Add drainage system	Chiseling and subsoiling (324) Subsurface drain (606) Surface drainage-field ditch (607) Surface drainage-main or lateral (608)
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)
Problem/Indicators	**Possible Reason for Low Ranking**	**Suggestions to Improve Soil Quality**	**Possible NRCS FOTG Practices***
Problem: Sodium Indicators to test: Soil structure Soil pH SAR	Seeps Shallow water table Low calcium irrigation water Poor drainage	For sodium problem, apply gypsum and leach with irrigation water Manage irrigation water Improve irrigation water quality 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) Nutrient management (590)
Problem: Tilth/soil stability Indicators to test: Aggregate stability Slake test Structure index	Low residues Low organic matter Excess tillage Fallow Compaction	Increase organic residues Use cover crops Add animal manure Reduce number of tillage passes Avoid tillage when wet	Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340)
Problem: Soil fertility Indicators to test: Organic carbon Soil pH Soil fertility test CEC	Nutrient imbalances (deficiencies or excesses) Poor drainage Poor or limited soil microbial activity Incorrect pH Low organic matter	Soil test - correct nutrient and pH levels Increase organic residue Use animal manure Use cover crops & crop rotations Reduce tillage	Nutrient management (590) Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340) Filter Strips (393) Contoured buffer strips (332)

Problem: Available water holding capacity Indicators to test: Organic carbon Water content at field capacity Porosity	Compaction Low organic matter Excessive drainage Low aggregation Low biological activity	Reduce compaction Increase organic residues Add animal manure Use cover crops Improve conditions for earthworms/soil life Avoid tillage when soil is wet	Chiseling and subsoiling (324) Residue management (329A, B, C, and D) Conservation crop rotation (328) Cover and green manure crop (340)

*Possible Practices refer to NRCS practices found in the NRCS Field Office Technical Guide

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	Easy	No-Physical and	Moderate to	Low	High reliability and	Need help to

	(15-30 min.) Results: 2-3 weeks		biological indicators require specialty analysis	Expensive; variable		precision, professional recommendations accompany results for some tests.	interpret, need outside lab, all tests not available, potential high costs for repeated tests	

NRCS Soil Health Card Template

Operator Name____________________ **Date of Visit_____________** **Field/Farm ID_________**

INDICATOR	RANKING			SCORING		
	Low	**Medium**	**High**	**Circle one**		
Earthworms	Few worms per shovel, no casts or holes	More worms per shovel, some casts or holes	Many worms per shovel, many casts or holes.	L	M	H
Soil Organisms	Few insects, worms, fungi, or soil life	Some insects, worms, fungi, soil life	Many insects, worms, fungi, soil full of variety of organisms	L	M	H
Smell	Swampy smell	Little or no smell	Fresh earthy smell	L	M	H
Surface Organic Material	No visible roots or residue	Some residue	Lots of roots/residue in many stages of decomposition	L	M	H
Residue Decomposition	Very slow decomposition, or rapid decomposition	Some visible, non-decomposed residue	Residue at various stages of decomposition	L	M	H
Compaction	Hard layers, tight soil, restricted root penetration, obvious hardpan, roots turned awkwardly	Firm soil, slightly restricted root penetration, moderate shovel resistance and penetration of wire flag beyond tillage layer	Loose soil, unrestricted root penetration, no hardpan, mostly vertical root plant growth	L	M	H
Workability	Many passes and horse-power needed for good seedbed, soil difficult to work	Soil works reasonably well	Tills easily and requires little power to pull implements	L	M	H
Soil Tilth/Structure	Soil clods difficult to break, crusting, tillage creates large clods, soil falls apart in hands, very powdery	Moderate porosity, some crusting, small clods, soil breaks apart with medium pressure	Soil crumbles well, friable, porous	L	M	H

Soil Aggregates	Soil surface is hard, clumps and does not break apart, very powdery	Soil crumbles in hand, few aggregates	Soil surface has many soft small aggregates which crumble easily	L	M	H

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

INDICATOR	RANKING			SCORING		
	Low	Medium	High	Circle one		
Plant Roots	Poor growth/structure, brown or mushy roots	Some fine roots, mostly healthy	Vigorous, and healthy root system, good color	L	M	H
Root Mass	Very few roots, mostly horizontal	More roots, some vertical, some horizontal	Many vertical and horizontal roots, deep roots	L	M	H
Salts	Visible salt/alkali, dead plants	Stunted growth, signs of leaf burn from salts	No visible salt, alkali or plant damage especially after rains	L	M	H
Sodium	Soil surface seals after rain or irrigation, fluffy when dry, uneven crop stand	Only some spots with sealed surface	No sealing or fluff at surface, no plant damage	L	M	H
Other				L	M	H
Other				L	M	H

NOTES:

1) Take all measurements under adequate moisture conditions (e.g., not excessively dry or wet).
2) Certain measurements, such as soil life, earthworms, structure, and tillage are affected greatly by field operations. They should be assessed before major tillage operations.
3) Select the best time for assessment and take measurements at the same time every year. See Maryland Card for an example of assessment time or calendar.
4) Include only regionally relevant indicators and descriptive terms.
5) This list is not all-inclusive. Add indicators as necessary, and leave blank spaces for field determined indicators.

For information about local farmer cards and conducting a farmer focus group to develop a Soil Health Card for your region, please visit the Soil Quality Institute Web site at **http://soils.usda.gov/sqi.**

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.

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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.

Indicator Table

Indicator	Poor	Medium	Good
Earthworms	0-1 worms in shovelful of top foot of soil. No casts or holes.	2-10 in shovelful. Few casts, holes, or worms.	10+ in top foot of soil. Lots of casts and holes in tilled clods. Birds behind tillage.
Organic Matter Color	Topsoil color similar to subsoil color.	Surface color closer to subsoil color.	Topsoil clearly defined, darker than subsoil.
Organic Matter Roots/Residue	No visible residue or roots	Some residue few roots	Noticeable roots and residue
Subsurface Compaction	Wire breaks or bends when inserting flag.	Have to push hard, need fist to push flag in.	Flag goes in easily with fingers to twice the depth of plow layer.
Soil Tilth Mellowness Friability	Looks dead. Like brick or concrete, cloddy. Either blows apart or hard to pull drill through.	Somewhat cloddy, balls up, rough pulling seedbed.	Soil crumbles well, can slice through, like cutting butter. Spongy when you walk on it.
Erosion	Large gullies over 2 inches deep joined to others, thin or no topsoil, rapid run-off the color of soil.	Few rills or gullies, gullies up to two inches deep. Some swift runoff, colored water.	No gullies or rills, clear or no runoff.
Water Holding Capacity	Plant stress two days after a good rain.	Water runs out after a week or so.	Holds water for a long period of time without puddling.
Drainage, Infiltration	Water lays for a long time, evaporates more than drains, always very wet ground.	Water lays for short period of time, eventually drains.	No ponding, no runoff, water moves through soil steadily. Soil not too wet, not too dry.
Crop Condition (How well it grows)	Problem growing throughout season, poor growth, yellow or purple color.	Fair growth, spots in field different, medium green color.	Normal healthy dark green color, excellent growth all season, across field.
pH	Hard to correct for desired crop.	Easily correctable.	Proper pH for crop.
Nutrient Holding Capacity	Soil tests dropping with more fertilizer applied than crops used.	Little change or slow down trend.	Soil tests trending up in relation to fertilizer applied and crop harvested.

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 ______________________________

Assessment Sheet

Date____________ Crop_________________

Farm/Field ID __________________________

Soil Quality *INDICATORS*	**Poor** 1	2	3	**Medium** 4	5	6	**Good** 7	8	9	
Earthworms										
Organic Matter Color										
Organic Matter Roots/residue										
Subsurface Compaction										
Tilth/Friability Mellowness										
Erosion										
Water Holding Capacity										
Drainage Infiltration										
Crop Condition										
pH										
Nutrient Holding Capacity										
Other (write in)										
Other (write in)										

Other farmer-produced soil health cards can be found at the Soil Quality Institute Web site at:
http://soils.usda.gov/sqi