Soil Quality Information Sheet

Soil Quality Resource Concerns: Hydrophobicity

USDA Natural Resources Conservation Service **June 2000**

What are hydrophobic soils?

Soils that repel water are considered hydrophobic. A thin layer of soil at or below the mineral soil surface can become hydrophobic after intense heating. The hydrophobic layer is the result of a waxy substance that is derived from plant material burned during a hot fire. The waxy substance penetrates into the soil as a gas and solidifies after it cools, forming a waxy coating around soil particles. The layer appears similar to non-hydrophobic layers.

Plant leaves, twigs, branches, and needles form a layer of litter and duff on the forest floor and under chaparral and shrubs. During the interval between one fire and another, hydrophobic substances accumulate in this layer. During an intense fire, these substances move into the mineral soil. Some soil fungi excrete substances that make the litter and surface layer repel water.

Why is hydrophobicity important?

Fire-induced water repellency can affect soil and the watershed.

- Hydrophobic soils repel water, reducing the amount of water infiltration.
- Decreased infiltration into the soil results in damaging flows in stream channels.
- Erosion increases with greater amounts of runoff, and much of the fertile topsoil layer is lost.
- Increased runoff carries large amounts of sediment that can spread over lower lying areas, clog stream channels, and lower water quality.
- Depending on the intensity of the fire, hydrophobic layers can persist for a number of years, especially if they are relatively thick. A smaller amount of water will penetrate the soil and be available for plant growth.

What affects the development of hydrophobic layers?

Not all wildfires create a water-repellent layer. Four factors commonly influence the formation of this layer. These include:

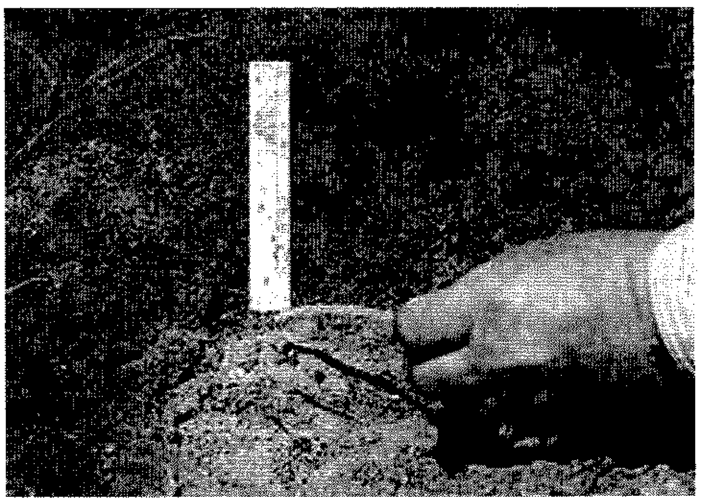
- A thick layer of plant litter prior to the fire
- High-intensity surface and crown fires
- Prolonged periods of intense heat
- Coarse textured soils

Very high temperatures are required to produce the gas that penetrates the soil and forms a hydrophobic layer. The gas is forced into the soil by the heat of the fire. Soils that have large pores, such as sandy soils, are more susceptible to the formation of hydrophobic layers because they transmit heat more readily than heavy textured soils, such as clay. The coarse textured soils also have larger pores that allow deeper penetration of the gas.

The hydrophobic layer is generally ½ inch to 3 inches beneath the soil surface and is commonly as much as 1 inch thick. Some hydrophobic layers are a few inches thick. The continuity and thickness of the layer vary across the landscape. The more continuous the layer, the greater the reduction in infiltration.

How are these layers detected?

Scrape away the ash layer and expose the mineral soil surface. Place a drop of water on air-dry soil and wait 1 minute. If the water beads, the soil layer is hydrophobic. The upper few inches of the soil commonly are not hydrophobic. In these cases, it is necessary to scrape away a layer of soil ½ to 1 inch thick and repeat the test to find the upper boundary of the water-repellent layer. Once a water-repellent layer is found, continue to scrape additional layers of soil, repeating the water drop test on each layer until a non-hydrophobic layer is reached. This procedure will indicate the thickness of the hydrophobic layer.



Considerations for rehabilitation

The amount of vegetative cover, woody material, soil texture, soil crusting, surface rocks, and slope of the land should be considered in any rehabilitation work. The combination of these factors along with the extent and thickness of the hydrophobic layer determine the likelihood of increased runoff, overland flow, erosion, and sedimentation.

Thicker layers will persist for more than a year and will continue to have an impact on infiltration as well as plant growth. Plant roots, soil micro-organisms, and soil fauna break down the hydrophobic layer. The reduction in water infiltration decreases the amount of water available for the plant growth and soil biological activity that break down the hydrophobic layer.

Treatment

- Place fallen logs across the slope to slow runoff water and intercept sediment.
- On level or gentle slopes, rake or hoe the upper few inches of the soil to break up the water-repellant layer and thus allow water to penetrate the soil for seed germination and root growth.
- On gentle and steep slopes, scatter straw mulch to protect the soil from erosion. Anchor the straw to hold it in place.
- Other practices that control erosion and reduce runoff include seeding, straw bale check dams, and silt fences.

(Prepared by the USDA NRCS Soil Quality Institute)

For more information on soil quality: http://soils.usda.gov/sqi/

Soil Quality Information Sheet

Indicators for Soil Quality Evaluation

USDA Natural Resources Conservation Service **April 1996**

What are indicators?

Soil quality indicators are physical, chemical, and biological properties, processes, and characteristics that can be measured to monitor changes in the soil.

The types of indicators that are the most useful depend on the function of soil for which soil quality is being evaluated. These functions include:
- providing a physical, chemical, and biological setting for living organisms;
- regulating and partitioning water flow, storing and cycling nutrients and other elements;
- supporting biological activity and diversity for plant and animal productivity;
- filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials; and
- providing mechanical support for living organisms and their structures.

Why are indicators important?

Soil quality indicators are important to:
- focus conservation efforts on maintaining and improving the condition of the soil;
- evaluate soil management practices and techniques;
- relate soil quality to that of other resources;
- collect the necessary information to determine trends;
- determine trends in the health of the Nation's soils;
- guide land manager decisions.

What are some indicators?

Indicators of soil quality can be categorized into four general groups: visual, physical, chemical, and biological.

Visual indicators may be obtained from observation or photographic interpretation. Exposure of subsoil, change in soil color, ephemeral gullies, ponding, runoff, plant response, weed species, blowing soil, and deposition are only a few examples of potential locally determined indicators. Visual evidence can be a clear indication that soil quality is threatened or changing.

Physical indicators are related to the arrangement of solid particles and pores. Examples include topsoil depth, bulk density, porosity, aggregate stability, texture, crusting, and compaction. Physical indicators primarily reflect limitations to root growth, seedling emergence, infiltration, or movement of water within the soil profile.

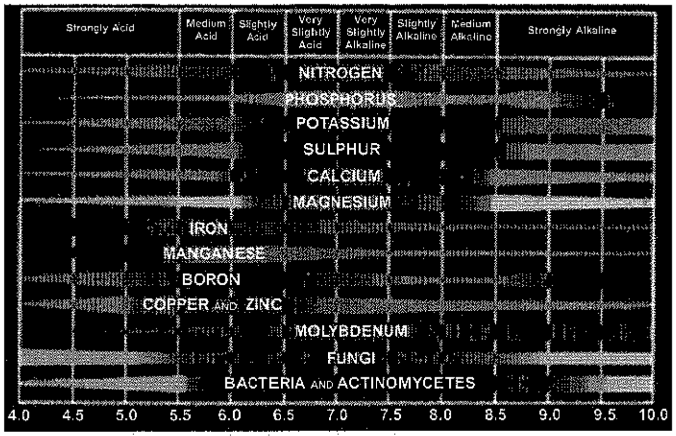
Chemical indicators include measurements of pH, salinity, organic matter, phosphorus concentrations, cation-exchange capacity, nutrient cycling, and concentrations of elements that may be potential contaminants (heavy metals, radioactive compounds, etc.) or those that are needed for plant growth and development. The soil's chemical condition affects soil-plant relations, water quality, buffering capacities, availability of nutrients and water to plants and other organisms, mobility of contaminants, and some physical conditions, such as the tendency for crust to form.

Biological indicators include measurements of micro- and macro-organisms, their activity, or byproducts. Earthworm, nematode, or termite populations have been suggested for use in some parts of the country. Respiration rate can be used to detect microbial activity, specifically microbial decomposition of organic matter in the soil. Ergosterol, a fungal byproduct, has been used to measure the activity of organisms that play an important role in the formation and stability of soil aggregates. Measurement of decomposition rates of plant residue in bags or measurements of weed seed numbers, or pathogen populations can also serve as biological indicators of soil quality.

How are indicators selected?

Soil quality is estimated by observing or measuring several different properties or processes. No single property can be used as an index of soil quality.

The selection of indicators should be based on:
- the land use;
- the relationship between an indicator and the soil function being assessed;
- the ease and reliability of the measurement;
- variation between sampling times and variation across the sampling area;
- the sensitivity of the measurement to changes in soil management;
- compatibility with routine sampling and monitoring;
- the skills required for use and interpretation.



Soil reaction influence on availability of plant nutrients.

When and where to measure?

The optimum time and location for observing or sampling soil quality indicators depends on the function for which the assessment is being made. The frequency of measurement also varies according to climate and land use.

Soil variation across a field, pasture, forest, or rangeland can greatly affect the choice of indicators. Depending on the function, such factors as the landscape unit, soil map unit, or crop growth stage may be critical. Wheel tracks can dramatically affect many properties measured for plant productivity. Management history and current inputs should also be recorded to ensure a valid interpretation of the information.

Monitoring soil quality should be directed primarily toward the detection of trend changes that are measurable over a 1- to 10-year period. The detected changes must be real, but at the same time they must change rapidly enough so that land managers can correct problems before undesired and perhaps irreversible loss of soil quality occurs.

What does the value mean?

Interpreting indicator measurements to separate soil quality trends from periodic or random changes is currently providing a major challenge for researchers and soil managers. Soils and their indicator values vary because of differences in parent material, climatic condition, topographic or landscape position, soil organisms, and type of vegetation. For example, cationexchange capacity may relate to organic matter, but it may also relate to the kind and amount of clay.

Establishing acceptable ranges, examining trends and rates of change over time, and including estimates of the variance associated with the measurements are important in interpreting indicators. Changes need to be evaluated as a group, with a change in any one indicator being evaluated only in relation to changes in others. Evaluations before and after, or with and without intervention, are also needed to develop appropriate and meaningful relationships for various kinds of soils and the functions that are expected of them.

The overall goal should be to maintain or improve soil quality without adversely affecting other resources.

(Prepared by the National Soil Survey Center in cooperation with the Soil Quality Institute, NRCS, USDA, and the National Soil Tilth Laboratory, Agricultural Research Service, USDA)

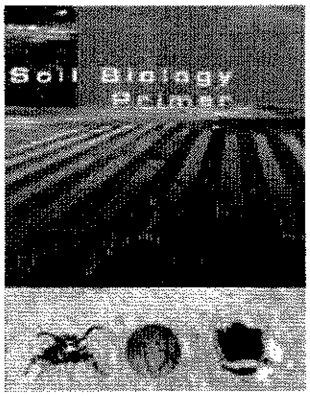
United States Department of Agriculture
NRCS Natural Resources Conservation Service

Soil Quality

Soil Biology

The creatures living in the soil are critical to soil quality. They affect soil structure and therefore soil erosion and water availability. They can protect crops from pests and diseases. They are central to decomposition and nutrient cycling and therefore affect plant growth and amounts of pollutants in the environment. Finally, the soil is home to a large proportion of the world's genetic diversity.

The Soil Biology Primer - On-line Version



The *Soil Biology Primer* is an introduction to the living component of soil and how it contributes to agricultural productivity, and air and water quality. The Primer includes units describing the soil food web and its relationship to soil health, and units about bacteria, fungi, protozoa, nematodes, arthropods, and earthworms. This booklet is suitable for a broad audience including farmers, ranchers, agricultural professionals, resource specialists, conservationists, soil scientists, students, and educators.

Use the navigation links to the left to access The Web-based version of the *Primer.* This on-line version includes all the text of the original but not all the images of soil organisms. The full story of the soil food web is more easily understood with the help of the illustrations in the printed version.

Clip art from the Primer is available for downloading.

The Soil Biology Primer - Printed Version

The *Primer* is published by the Soil and Water Conservation Society (SWCS). You can order the *Primer* from the SWCS web site at www.swcs.org (mouse click on Publications and then Books), or call 1-800-THE-SOIL, or e-mail pubs@swcs.org.

How to Cite the Soil Biology Primer

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Authors
Elaine R. Ingham
Andrew R. Moldenke, Oregon State University
Clive A. Edwards, The Ohio State University

Editors
Arlene J. Tugel, NRCS Soil Quality Institute
Ann M. Lewandowski, NRCS Soil Quality Institute
Deb Happe-vonArb, Soil and Water Conservation Society

Designer
DesignGroup Inc.

Illustrations
Nancy K. Marshall, Marshall Designs

Reviewers (Not all reviewed all chapters)
Jayne Belnap, National Park Service
Edwin Berry, USDA-ARS, National Soil Tilth Lab, Ames, IA
David C. Coleman, University of Georgia
Jeff Herrick, USDA-ARS, Las Cruces, NM
Ann Kennedy, USDA-ARS, Pullman, WA
Dennis Linden, USDA-ARS,St. Paul, MN
Jean Molina, University of Minnesota
Kate Scow, University of California, Davis

Soil Biology Technical Notes

The Soil Biology Technical Notes are a series of technical publications designed to provide additional information about soil biology. The notes are listed on the Soil Quality Products page.