Understanding Soil and Soil Health

Neith Little, Extension Educator, University of Maryland - Urban Agriculture

How well you understand soil, and how well you manage the soil's health, will have a large impact on the productivity of the farm. This section will introduce key concepts that will help understand soils and good farming practices that will help manage overall soil health.

What is soil?

Soil is the result of a mind-bogglingly long process wherein the rocks of the earth's crust are gradually broken down into very small particles by the environment and living organisms. Soil is made of tiny particles of rock (sand, silt, and clay are size classes of tiny rock particles), dead biological material (organic matter), and living organisms (from "macroinvertebrates" like worms down to microbes, fungi, and viruses).

How can I learn about my soil?

Soils have physical and chemical properties that affect how well the soil can grow plants. Important soil properties include layers, depth, texture, structure, compaction, density, fertility, pH, cation exchange capacity (CEC), organic matter, drainage, and water holding capacity. Additional references to help you learn about some of these properties are listed below in the *Additional Reading* section.

You can get a rough assessment of some soil properties by looking at the soil itself. A soil laboratory can conduct more precise tests of your soil's properties which will give you more accurate, actionable results. The following paragraphs will describe some of these resources in more detail.

In Maryland, the geographic location of your farm will dramatically affect what kind of soil you have to work with. Broadly, Maryland can be broken up into three soil categories: Appalachian Mountains, Piedmont plateau, and Coastal Plain (Fig. 1). A lot of soil diversity exists within these regions, but in general mountain soils tend to be more rocky and steep, the Piedmont plateau tends to be gently hilly with many small streams and a loamy soil texture, and the coastal plain tends to be marshy with patches of mostly sand texture and patches of mostly clay texture.

To find detailed information about the soil on your specific farm, the best place to start is the Web Soil Survey, which is a searchable digital soil map operated by the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). Read in particular what the soil map says about your soil's texture, drainage class, and slope.

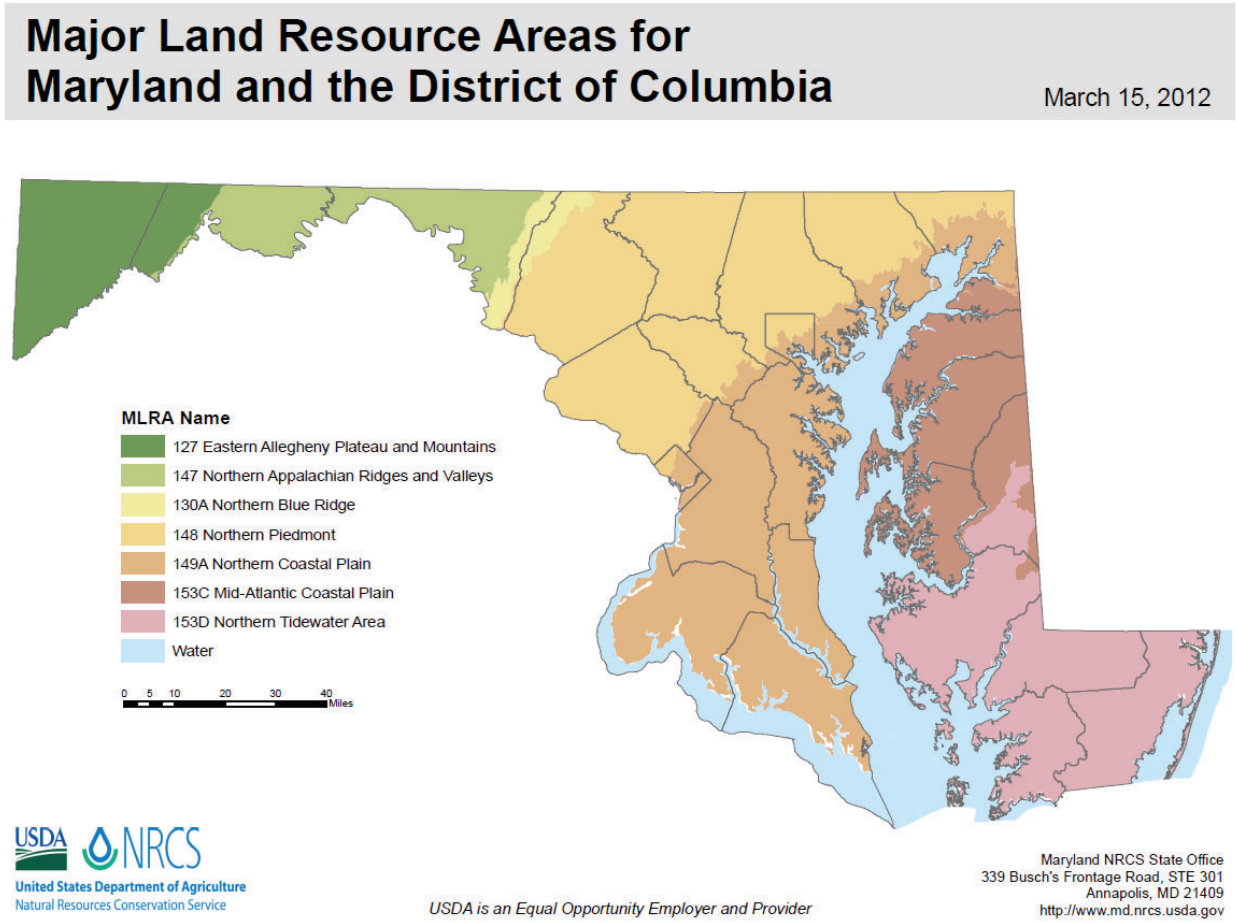

Figure 1: Maryland's soil regions, as mapped by the USDA-NRDCs. Broadly, Maryland can be broken up into three soil categories: mountains (127,147,130A), Piedmont plateau (138), and coastal plain (149A,153C, 153D).

Texture is arguably the most important property of a soil. A soil's texture is its ratio of sand, silt, and clay (the different size classes of soil particles). At the scale of a farm field soil texture is impossible to change, and soil texture affects many of the other properties, such as drainage, water holding capacity, and fertility. For more information about soil texture, see the *Additional Reading* below.

Note that in small fields and in urban areas the soil maps on the Web Soil Survey may not be as accurate. It is important to check how the Web Soil Survey predicts the soil within an area. Both quick field methods and accurate lab methods have a role to play in this process. Field-based soil quality measurement methods are fast, inexpensive tools to get a qualitative "feel" for your farm and laboratory soil testing methods are the gold-standard for quantitatively measuring your soil's properties so that you can make informed management decisions. The USDA-NRCS offers detailed information about both field-based and laboratory soil analysis methods: https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/

Soil testing

Different testing methods are used to measure different qualities of the soil. There is no one soil test that will tell you everything. Before doing a soil test, you need to know what soil property to measure. The most common test is a soil fertility test, which typically measures a soil's pH, organic matter, and nutrient availability. All three of these soil properties are extremely important to the soil's fertility -- its ability to grow high yielding, high quality crops.

The pH scale is a measure of the balance of hydrogen ions (H+) and hydroxide ions (HO-) in the soil. At the low end of the pH scale, there are many hydrogen ions and the soil is considered acidic. At the high end of the pH scale there are many hydroxide ions and the soil is considered basic. A moderate pH, between 6 and 7, is ideal for most crops. In this pH range, plant nutrients are most available to the plants' roots, and elements that are toxic to plants, like aluminum, are bound tightly to the soil particles. For more about pH, and how to get it in that ideal range, see the *Additional Reading* section below.

Organic matter is dead biological material in varying states of decay. Organic matter is an important source of slow-release nutrients for plants and other organisms in the soil. Organic matter also increases the soil's water holding capacity and can improve soil structure. An organic matter measurement of 3 to 4% is considered good. For more on how organic matter affects soil quality, see the *Additional Reading* section below.

Plants need nutrients, like nitrogen (N), phosphorus (P), and potassium (K) to build their bodies. A soil fertility test will report the amount of "plant available nutrients." This is different from the total amount of nutrients in the soil, because a large proportion of the nutrients are bound into minerals and organic matter where the plant roots cannot access them. These bound up nutrients may become available in future years, but they will not be available in the current growing season. Soil fertility test methods have been developed to estimate the amount of nutrients that are available to plants, and to predict whether adding additional nutrients will increase crop yields.

Different soil fertility tests have been developed to be specific to the soils and climate of different geographic regions. This is why it is important to use a soil testing lab recommended for your state. For example, the plant nutrient nitrogen is very mobile in water, and here in Maryland we get a lot of rain. Because of this, in Maryland by the time you collect a soil sample, mail it off to the lab, and get your soil fertility test results back, the amount of available nitrogen in the soil has probably already changed. For this reason, in Maryland most soil tests will not report nitrogen availability and will instead recommend adding nitrogen to your soil based on book values for how much nitrogen different crops will need. It is also recommended to add nitrogen in small amounts throughout the season, so that it is less likely to be lost before your plants can take it up. Building up soil organic matter and incorporating nitrogen-fixing leguminous cover crops into your crop rotation are also good ways to provide some slow-release nitrogen to your crops.

Before you decide whether to add nutrients to your soil using fertilizers or composts, it is important to know that in Maryland farmers who sell at least $2,500 worth of crops per year, or who raise a certain amount of livestock, are legally required to have and follow an approved nutrient management plan. The University of Maryland Agricultural Nutrient Management Program can help you comply with this requirement, and plan how to provide your crops the amount of nutrients that they need to grow well.

Farming practices that improve soil health

Above you read about how to test soil fertility and how to improve its pH, organic matter, and nutrient availability. Additional farming practices that can improve soil health include minimizing tillage and incorporating cover crops into your crop rotation. Reducing tillage helps build soil structure and reduce compaction. This is important, because plant roots need both air and water, and when soil has poor structure or is compacted, there is little space in the soil for air and water, and plant roots have difficulty growing. Cover crops increase soil organic matter, help build good soil structure, and feed the many organisms that live in the soil. A healthy soil ecology is important for nutrient supply and for suppression of pests and diseases.

To learn more about soil health, and practices you can adopt to improve your soil, see the *Additional Reading* section below.

Additional reading on soil management and soil health:

- **Soils** Cornell Cooperative Extension Agronomy Fact Sheets, http://nmsp.cals.cornell.edu/guidelines/factsheets.html
- **Guide to soil texture by feel,** USDA-NRCS, https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/edu/
- **Soil organic matter is an essential component of soils.** UMD Extension factsheet 1045, by Jarrod Miller, https://go.umd.edu/FS1045
- **Soil pH affects nutrient availability.** UMD Extension Factsheet 1054, by Jarrod Miller, https://go.umd.edu/FS1054
- **Soil pH management and determining liming rates.** UMD Extension Soil Fertility Management Bulletin 5. https://go.umd.edu/SFM5
- **Lowering soil pH for horticulture crops.** Purdue Extension HO-241-W, by Michael V. Mickelbart and Kelly M. Stanton. https://go.umd.edu/PurduesoilpH
- University of Maryland Extension **Agricultural Nutrient Management Program** (UME-ANMP): https://extension.umd.edu/anmp
- UME-ANMP **Soil Testing recommendations:** https://extension.umd.edu/learn/2-soil-sampling-and-testing
- **Precision soil sampling helps target nutrient application.** UMD Extension Factsheet 1046, by Jarrod Miller and Craig Yohn, https://go.umd.edu/FS1046
- **Manure as a natural resource: Alternative management opportunities.** UMD Extension Bulletin 420, by Jarrod Miller, https://go.umd.edu/EB420

- **Comprehensive assessment of soil health**. Cornell University, by Bianca Moebius-Clune, D. Moebius-Clune, and colleagues. http://soilhealth.cals.cornell.edu/training-manual/
- **Soil Health website** of the United States Department of Agriculture--Natural Resources Conservation Service (USDA-NRCS). https://go.umd.edu/NRCSsoilhealth
- **Building Soils for Better Crops** by Fred Magdoff and Harold van Es, published by Sustainable Agriculture Research and Education (SARE). https://go.umd.edu/buildingsoils
- **Managing Cover Crops Profitably** by Greg Bowman, Craig Cramer, and Christopher Shirley, published by SARE. https://go.umd.edu/covercropsSARE