# Green Lands Blue Waters GAINING GROUND

# Soil Pit Demo Handbook

## Introduction

This guide is intended for educators, scientists, and agricultural professionals who are looking to teach about soil properties and functions in an engaging, demonstrative way through soil pits.

## What is a soil pit?

A soil pit is an excavated hole in the earth that exposes layers of soil, especially within the plant rooting zone. Soil pits range in size, but for educational purposes, are commonly 4+ feet deep and 8-10 feet long. These pits are typically used by educators and scientists for education on landscape processes and management impacts to the soil, and for sampling and observation of exposed soil attributes.

*Soil pit in Hampton, MN. Credit: UMN Extension*


## Why and where to use a soil pit

Soil pits are a valuable tool for learning about the soils beneath our feet. By exposing a full soil profile, we can directly observe the horizons, structure, and biological activity that are normally hidden from view. This allows participants to connect what they see above ground, such as crop growth, water movement, or vegetation patterns, with the underlying soil characteristics that support or limit those processes. This engaging demonstration makes soil science tangible and directly relevant to management decisions.

**Soil tests vs soil pits:** While laboratory soil tests are common tools for assessing surface chemical properties (nutrients and pH) and physical properties (soil texture and organic matter content), they often only evaluate the top 6 inches of soil. These tests examine soil properties but do not assess soil functions such as water infiltration, soil stability, biological habitat suitability, and other functions based on the three-dimensional arrangement of soil. Soil tests also fail to tell us about conditions in the rooting zone if we do not test deep enough. Soil pits allow us to assess the management zone and the deeper rooting zone, providing information to make more informed management decisions.

Soil pits can be used in a variety of settings. Permanent soil pits may be used at research stations, school campuses, and camps for repeated use with multiple audiences. Temporary soil pits may be used for educational events such as field days and workshops, for research purposes, or simply out of curiosity.

Soil pit demonstrations can help audiences:

- Understand soil formation processes and landscape influences.
- Distinguish between inherent and dynamic soil properties.
- Identify and interpret soil horizons and textures.
- Connect soil physical, chemical, and biological properties to land management decisions.
- Recognize signs of soil health and degradation.

This guide details the process of digging a soil pit and planning an accompanying educational demonstration in an agricultural setting. However, many of the same principles will also apply to soil pits in different settings.

## Planning a Soil Pit

### Location

When selecting a soil pit location, consider:

**Landowner needs and preferences** – Make sure to actively include the landowner in conversations about a soil pit on their land. Some landowners or land managers may not want a soil pit on their property. Receive written consent from all involved parties before finalizing the soil pit location. In your conversations with the landowner, discuss what a soil pit can reveal, what information they want to know, which areas are okay to dig in, and other logistical considerations.

**Your primary goals for having a soil pit** – Sometimes it is useful to have multiple pits to showcase your main point. For example, if you want to show erosion, you could dig a soil pit at various hillslope positions such as the shoulder and/or footslope to showcase that the eroded soil removed from the shoulder position has been transported and accumulated downslope.

**What is feasible for the digger** – The site should be easy for the digging equipment and operator to access. Some digging machinery is large and may not be able to drive across rough terrain or steep hills. The safety of the digging personnel should always be the top priority.

**The main use of the site** – Be aware of the purpose of the site so that you do not greatly interfere with its normal operation. For example, you should avoid digging a pit in a corn field during the middle of the growing season, as you would likely disturb a large area of crop. You aren't just impacting the spot that you dig, but also the area of the field that you are driving over.

**Participant access** – Ensure that participants with different levels of mobility are able to access the site. The site should also have enough space for participants to stand around the pit to see inside.

*Soil pit in Faribault, MN. Credit: UMN Extension*

## Orientation and Dimensions

After determining the location for the soil pit, the next considerations are the orientation and dimensions. Orient the soil pit for optimal viewing conditions of the soil profile. Consider the time of day that the audience will visit the pit. Generally, the sun should be behind the pit face so audience shadows do not block the view of the soil. If the soil pit will be in a row crop setting, it should be oriented perpendicular to the direction of the rows. This allows for multiple instances of plants and roots to be shown. Do not orient the pit within the row, or you may risk not capturing the intended plant and root systems.

Choose soil pit dimensions that align with visibility and demonstration needs.

**Depth:** To best demonstrate crop roots and the soil profile, the soil pit should be at least 4 feet deep. If the soil pit is too deep compared to the width, the audience may not be able to see points of interest at the bottom of the pit. A more shallow soil pit may be warranted depending on conditions such as a high water table or shallow bedrock.

**Length:** In a row crop setting, the soil pit should cut across at least 4 rows of crop. In a pasture setting, the length should be at least 8-10 feet long.

**Width:** A soil pit should be a minimum of 5 feet wide. If less than 5 feet wide, the audience will not be able to see into the pit properly.

**Other considerations**

- Slope one end of the pit, create steps, or use a ladder so people can get in and out of the pit.
- The more people you expect, the longer and wider the pit should be so more people can see into the pit. Approximately 20-30 people can fit comfortably around a standard sized soil pit.
- Don't dig a pit larger than the land manager's tractor. The disturbed soil may settle after filling in the pit, and you don't want a farmer to get their tractor stuck.
- Before digging the pit, find a key area of interest for the farmer and your audience. You could choose a representative site, or may want to highlight a unique area. Ensure you provide useful information for the attendees and landowner.
- Before finalizing digging plans, call 811 to request marking of utility lines. Hitting a utility line can be costly or hazardous, so this is a crucial process to follow. Call 811 at least one week prior to digging the pit to give the service enough time to mark the utility lines.
- If the bottom of the soil pit is wet, sticky, or muddy, place plywood or a wooden shipping pallet at the bottom as a stable surface.

### Soil Pit Safety ⚠️

Soil pits are incredibly useful tools, but they also pose an inherent danger. Certain soil textures, like sands, are more prone to soil cave-ins which can be life-threatening. To help prevent cave-ins, avoid:

- Digging soil pits more than 5 feet deep.
- Digging soil pits only one bucket width wide.
- Heavy equipment or unnecessary people near the edge of the pit.

Soil pits also pose a falling risk. When not in use, mark the area around the pit with high-visibility snow fence or another visible border. Warning signs are also encouraged when the pit is not in use.

## Excavation

After deciding on the location, orientation, and dimensions of the soil pit, it's time to excavate the pit. Remember to call 811 before excavating to ensure the location is clear of buried utility lines.

While a soil pit can be dug by hand, it is easier and more efficient to use an excavator. An excavator is a great way to get a large hole dug, but requires proper equipment and training. To find an excavator or operator, check with a local rental center or contractor. If using an excavator, be sure it is available to dig the pit and fill the pit in once the demonstration is complete.

Determine the location where the material being removed from the soil pit should be placed. This material is also referred to as "spoil". The spoil pile should be placed next to or behind the pit, where attendees will not be standing. A spoil pile in front of the pit is not sightly, so it should be kept out of the way as much as is feasible. If possible, create two spoil piles: one with the darkened, organic matter-rich topsoil and another with the subsoil material.


Step 1: The farmer selects a location to dig a pit, and digs with a backhoe or trencher.


Step 2: The backhoe removes scoops of soil, keeping in mind the pit dimensions, and placing the topsoil in a separate pile from subsoil.


Step 3: The pit has been dug and now the farmer can dig steps or clean out the pit further.


Step 4: Wooden panels can be placed at the muddy bottom for trafficability.

*Soil pit demo field day, August 2023. Credit: UMN Extension*

## Filling in the Pit

When filling in the pit, place the subsoil material first and the topsoil last to most accurately restore the soil to its original state.

## Supply List

Below is a list of supplies that may be useful for digging or presenting in a soil pit. Not all items in the supply list are necessary, but they may be helpful.

- **Excavator** – To dig the majority of the soil pit.
- **Tarp** – To place the spoil pile on, to reduce disturbance to the surrounding soil.
- **Wood pallets** – To place in the bottom of the pit for better standing conditions when wet or muddy.
- **Shovel** – To clean off the sheared profile and to dig out any spoil that falls to the bottom of the pit.
- **Knife** – To clean off the sheared profile, pull out samples of interest, feel for structure and density differences through the profile, and point to features in the soil pit.
- **Tape measure** – To show the depth of different areas of interest in the soil. Flexible tape measures work best in a soil pit setting. Cloth tape measures with large print can be custom-ordered at a fabric supply store.
- **Golf tees or roofing nails** – To mark the location of soil horizons or points of interest.
- **Bowls or muffin tins** – To display samples for the audience to see close-up.
- **Spray bottle** – To moisten soil samples for hand-texturing and to display color.
- **Handouts** – To give to the audience to increase their understanding of the topics addressed. Relevant handouts may include soil texture triangles, hand-texturing flowcharts, soil structure diagrams, and other useful materials.
- **Demonstration aids** – To help increase the audience's understanding or skills within a certain topic. These may include costly items, like soil color books, that you do not want to give away to each attendee.

## Demonstration and Discussion Points

How you present a soil pit will differ based on your target audience. Potential audiences may include soil and agricultural professionals, farmers and ranchers, youth, or the general public. Keep in mind that these audiences have different needs and practical applications of the educational material.

Below are some discussion points that may be relevant when presenting a soil pit demonstration. Although most of these points will be applicable to many settings, be sure to do your research on the land history and management to ensure you can correctly interpret the features in the soil pit.

Terms and definitions can be found in the glossary at the end.

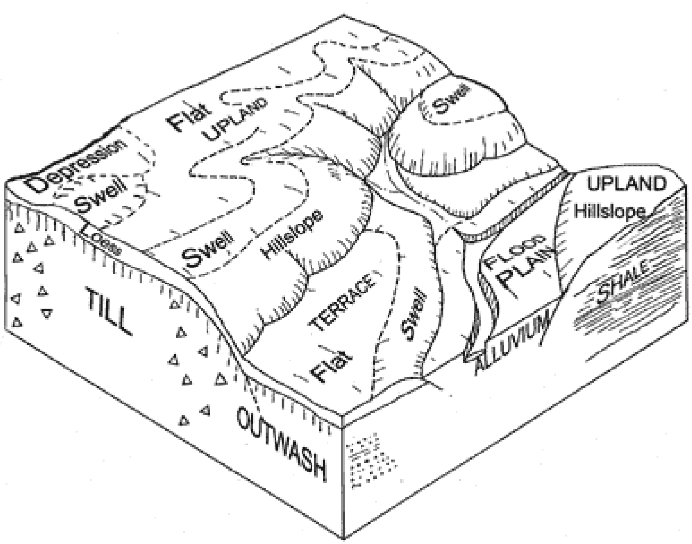
## Landscape position and history

**Goal**: Establish the landscape-scale setting of the soil pit to provide background on the reason for some of the observed soil features and functions.

**Discussion points**:

- What is the hillslope position?
  - Ex) Summit, shoulder, backslope, footslope, or toeslope
- Are there signs of past erosion or deposition?
  - Ex) Thinner top soil, buried horizons, exposed subsoil
- Are there glacial landforms present?
  - Ex) Kettles, kames, moraines, eskers
- What is the soil formation history?
  - Ex) Climate, organisms, relief (topography), parent material, and time

**Notes**: Connect the landscape history to the current soil appearance and functions. Hillslope position, presence of glacial landforms, and soil formation history will often dictate the direction of water movement through the landscape. Consider - If a raindrop falls, where will it run? Will it percolate, flow laterally, or run off? Information on landscape position and history can be found on Web Soil Survey, an online soil data exploration tool.




*Block diagram showing some parent materials, landforms, and landform components.*[1]

## Management history

**Goal**: Establish connections between management history and the features and functions of the soil.

**Discussion points**:

- Is there evidence of human impact on the soil horizons?
  - Ex) Fill material, plow layer, artifacts
- What has the land been used for?
  - Ex) Crop production, pasture, homestead
- How does soil management affect soil features and functions?
  - Ex) Water movement, water holding capacity, nutrient dynamics, root growth

**Notes**: Interview the landowner or manager to gather information on the management history. In a cropping system, helpful information may include tillage type, frequency, and intensity, crop rotation, livestock presence, and timeline of management changes. The Natural Resources Conservation Service Cropland In-Field Soil Health Assessment Guide includes example questions to help guide an interview with a landowner or manager about their management history.

## Soil horizon features

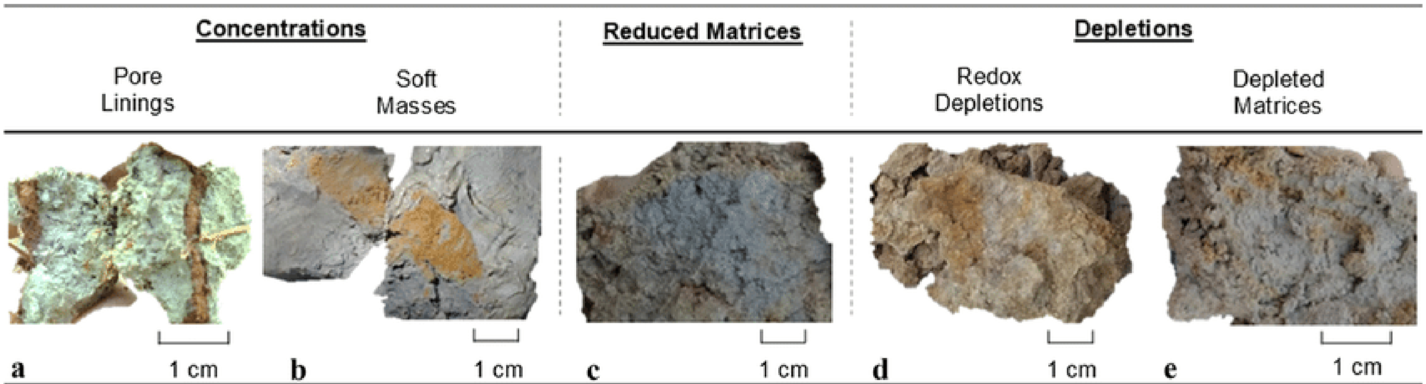
For each horizon (layer) in the soil pit, look for differences in color, texture, structure, roots, organisms, depth, and density. Note that the soil pit location, position, and management will impact these horizon features.

### Color

**Goal**: Use color to interpret organic matter levels, soil hydrology, and management history to understand what the soil has experienced and how it functions.

**Discussion points**:

- What color is each horizon?
  - Ex) Black, brown, tan, grey, yellow, red, white
- What can we infer from soil color?
  - Ex) Saturation, drainage, oxidation, past land use and vegetation cover




*Examples of each of the three main types of iron redoximorphic features: concentrations, including pore linings (a) and soft masses (b), reduced matrices (c), and depletions, which includes non-matrix redox depletions (d) and depleted matrices (e).*[2]

- Are there color variations within horizons?
  - Ex) Salts, such as calcium carbonate, may appear as white masses or threads and would react with hydrochloric acid.

**Notes**: Explain the various ways a soil can get its color, including parent material, organic matter, moisture, soil hydrology, minerals, and biological activity. If there are redoximorphic features in the soil pit, describe the process in which soil saturation dynamics and bacteria create these features. If you have access to a Munsell color book, use it to show and describe soil color, including hue, value, and chroma.

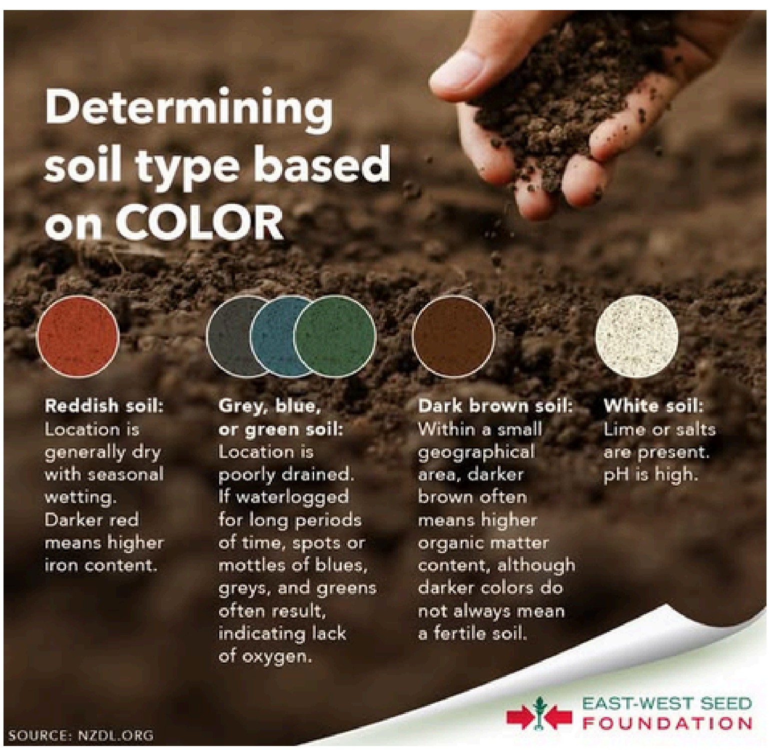



*Diagram showing various soil colors and associated properties.*[3]

## Texture

**Goal**: Help participants understand what soil texture is and how it impacts land management.

**Discussion points**:

- What is the soil texture of each horizon – is it gritty, smooth, or sticky?
  - Ex) Soil texture classification based on sand, silt, and clay percentages
- Does the texture change significantly between horizons? If so, why?
  - Ex) Eluvial and illuvial horizons
- How does soil texture affect water holding capacity and nutrient retention?
  - Ex) Sandy textures have low water-holding capacity and nutrient retention, while clayey soils have high water-holding capacity and nutrient retention.

**Notes**: Use the soil texture triangle to explain how the percentages of sand, silt, and clay form the overall texture. The soil texture by feel flowchart can be a useful tool to determine soil texture class and engage the audience in an activity. Soil texture is an important inherent feature of the soil – something that your soil is 'born with'. Erosion can add or remove soil layers of different textures, but our management does not directly impact soil texture. However, soil texture is a critical determinant of soil and crop management. Texture influences the amount of surface area in your soil to hold nutrients, organic matter, water, and air.

### Structure and pores

**Goal**: Connect soil structure and pore characteristics to land management and resource concerns.

**Discussion points:**

- What are the shape and size of the soil aggregates in each horizon?
  - Ex) Granular, blocky, platy, massive, single grained
- Is there evidence of biopores?
  - Ex) Tunnels formed by invertebrates, mainly earthworms
- How do soil structure and soil pores influence water movement, root penetration, and aeration?
  - Ex) Granular structure and soil pores allow for ideal air and water movement, as well as root penetration. Soil with poor structure and a lack of soil pores does not allow for proper air and water movement, and is difficult for roots to penetrate.
- How does land management affect soil structure?
  - Ex) Repeated tillage can cause compaction, leading to platy, blocky, or massive soil structure. Soil health practices like using cover crops and reduced tillage can lead to more granular structure.

**Notes**: Soil structure is a critically important feature for determining soil function. Note that there are large macropores that separate macroaggregates within the soil, and microaggregates that are within soil structure. As a dynamic soil property, structure changes with management. In a soil pit, look for evidence of compaction from heavy wheel traffic and repeated tillage to a particular depth. This can include platy structure at the surface or at the typical tillage depth, where a plow pan is formed in the soil.

### Soil depth

Goal: Connect soil depth to soil productivity and constraints.

**Discussion points**:

- How deep is each layer in the soil profile?
  - Ex) Topsoil, subsoil, depth to bedrock
- How does soil depth relate to function and productivity?
  - Ex) Deep topsoil and long depth to bedrock is better for agricultural uses, while shallow topsoil and short depth to bedrock may cause water drainage, nutrient, and plant rooting issues.

**Notes**: Soils that are shallow and close to bedrock have different resource concerns than deep soils. In glacial till landscapes, bedrock is not often a concern, but in other locations this may be more prevalent.

## Biological features

### Roots

**Goal**: Demonstrate the importance of root and soil interactions for soil processes and plant health.

**Discussion points**:

- How deep do roots extend in the soil profile? Are they abundant or sparse in certain layers?
  - Ex) Abundant roots in the top 4 inches, sparse roots between 4 to 12 inches
- What sizes of roots are present?
  - Ex) Fine, hair-like roots, or thick, coarse roots
- Is there evidence of barriers to root growth?
  - Ex) “J”-shaped root growth, platy structure, plow pan

**Notes**: Highlight the interaction between soil structure, pore space, and root growth. Plant roots tell us about the growing conditions within the soil. Not only are plant roots important for physically holding the soil in place and reducing erosion, but they can also be useful in determining if there is a root-restricting layer, a plow pan, or a high water table. If roots do not get adequate access to air, water, plant-available nutrients, and structural stability, plant health suffers and roots will wither or rot.

## Evidence of biological activity

**Goal**: Highlight the signs of biological activity in the soil and how management influences biological communities.

**Discussion points**:

- Are there signs of biological activity?
  - Ex) Earthworm channels or casts, insect burrows, visible fungal hyphae
- Are there signs of organic matter breakdown?
  - Ex) Decomposing roots or plant residues
- How does biological activity differ by depth?
  - Ex) Most biological activity is concentrated on the soil surface or in the rooting zone.

**Notes**: Connect the signs of biological activity to the management practices used in that area. The less the soil is disturbed and the more the ground is covered with living or dead plant matter, the more active, abundant, and diverse the biological community will be. Also, note the diversity of soil biology beyond macroinvertebrates visible to the naked eye. Soil biology also includes bacteria, fungi, protozoa, and nematodes, although these are best viewed with a microscope.

## Accompanying demonstrations

Demonstrations can be useful additions to a soil pit demonstration. The following demonstrations can be paired with a soil pit to teach about management practices and soil function.

- Slake and slump tests
- Rainfall simulators
- Dye tests

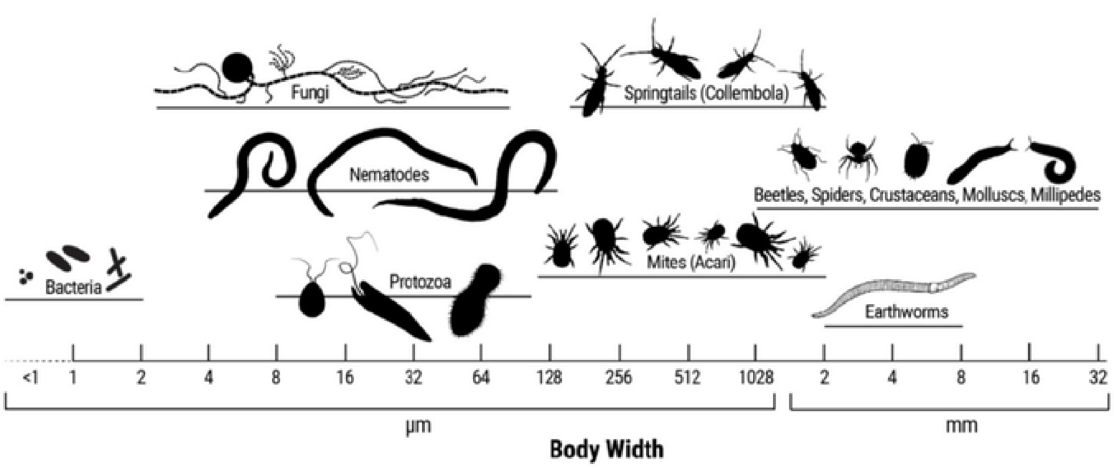
## Example of connecting features, function, and management

You will want to connect the features you observe in the soil pit to soil functions that affect plant health and soil management.

**Soil functions:**

- Medium for plant growth – Supplies water, air, and nutrients to plant roots
- Regulator of water supplies – Infiltrates and holds on to water, filters chemicals and sediment
- Recycler of raw materials – Allows for decomposition of organic materials such as leaves
- Habitat for soil organisms – Provides a home for beneficial microbes, bacteria, fungi, etc.
- Landscaping/engineering medium – Allows our built environment to be created

You can point out evidence of how soil management affects soil features and functions, and suggest management changes to alleviate resource concerns. For example, if you observe a compacted, dense subsoil layer, you may note that this is a plow pan resulting from repeated tillage. Then, connect this observed property to soil functions, such as reduced water infiltration and water-holding capacity, reduced rooting depth and stunted growth, and increased vulnerability to droughts. You may suggest reducing tillage intensity, reducing tillage passes, and planting cover crops to help mitigate tillage-induced soil resource concerns.




*Soil organisms grouped by class, showing the size of body width. Bacteria in the diagram represent all prokaryotes, bacteria and Archaea.*[4]

## Summary

Soil pits are one of the few ways we can see what's happening below the surface – how water moves, where roots grow, how nutrients cycle, and how soils change over time. Many management challenges can't be fully understood from surface observations or traditional sampling alone. Opening a soil pit lets us connect what we see in the soil to real management decisions, landscape conditions, and resource concerns. Using soil pits intentionally helps make learning hands-on and practical, and leads to better agronomic and conservation outcomes.

## Resources

- Soil health in-field cropland assessment
- Soil formation overview
- Soil texture and structure
- NRCS agronomic use of soil pit resource:
- NRCS 'From the Surface Down: An Introduction to Soil Surveys for Agronomic Use'

## References

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## Attributions and acknowledgements

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# Terms and definitions

## Soil horizons & profile

- **Soil profile**: A vertical section of soil showing all horizons from the surface down to parent material or bedrock.
- **Soil horizon**: A distinct layer in the soil formed by soil-forming processes. Horizons differ in color, texture, structure, and biological activity.
- **Eluvial horizon**: A soil horizon characterized by the removal of clay, iron, or organic matter from an horizon by water movement.
- **Illuvial horizon**: A soil horizon characterized by the accumulation of materials that were moved downward from upper horizons.
- **Parent material**: The geologic material from which soil develops, such as glacial till or outwash.
- **Bedrock**: Solid rock underlying soil layers.

## Landscape

- **Hillslope position**: The location of soil on a slope that affects drainage and soil formation.

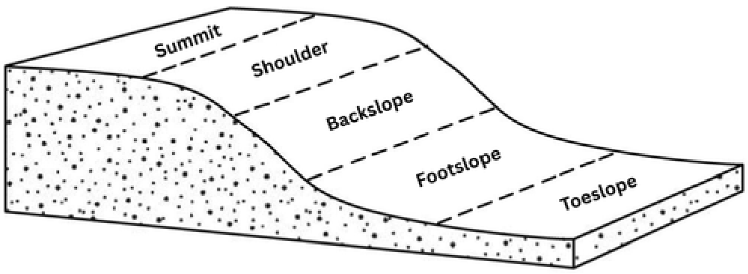


Figure*: Example of hillslope position on the landscape. Adapted from Bullied, Van Acker, and Bullock, 2021.*

## Soil physical properties

### Texture & particles

- **Soil texture**: The relative proportion of sand, silt, and clay particles in soil.
- **Texture triangle**: A diagram used to classify soil texture based on sand, silt, and clay percentages.
- **Hand texturing**: A field method for estimating soil texture by feel.

### Structure & aggregates

- **Soil structure**: The arrangement of soil particles into aggregates (peds) that influence water movement and root growth.
- **Aggregate (Ped)**: A natural clump of soil particles held together by organic matter, roots, or minerals.

### Compaction

- **Compaction**: Compression of soil that reduces pore space and limits root growth.
- **Plow pan:** A dense layer formed at the depth of repeated tillage.
- **Root-restricting laye**r: A compacted or dense soil layer that limits root penetration.

# Terms and definitions (continued)

## Hydrology & redox features

- **Water table**: The depth at which soil becomes saturated with water.
- **Saturation**: When soil pores are filled with water rather than air.
- **Infiltration**: The movement of water into the soil surface.
- **Percolation**: Downward movement of water through soil.
- **Runoff**: Water that flows across the soil surface instead of soaking in.
- **Macropores**: Large soil pores that allow rapid air and water movement.
- **Redoximorphic features**: Patterns of color formed by alternating wet and dry conditions.
- **Concentrations**: Areas where iron accumulates, often reddish.
- **Depletions**: Gray zones where iron has been removed.
- **Gleying**: Uniform gray or bluish soil color caused by prolonged saturation.

## Biological indicators

- **Biopores**: Channels created by roots or soil organisms that improve water and air movement.
- **Earthworm casts**: Soil deposited by earthworms on the surface or within pores.
- **Soil organic matter**: Living, dead, and decomposing plant and animal material that improves soil structure and fertility.
- **Fungal hyphae**: Threadlike fungal structures that help bind soil particles and cycle nutrients.
- **Residue**: Dead plant material left on or in the soil.

## Management & disturbance

- **Erosion**: Removal of soil by wind or water.
- **Deposition**: Accumulation of soil material transported from elsewhere.
- **Fill material**: Soil or debris added by human activity.