Soil Characterization:

Following this protocol, you and your students will:

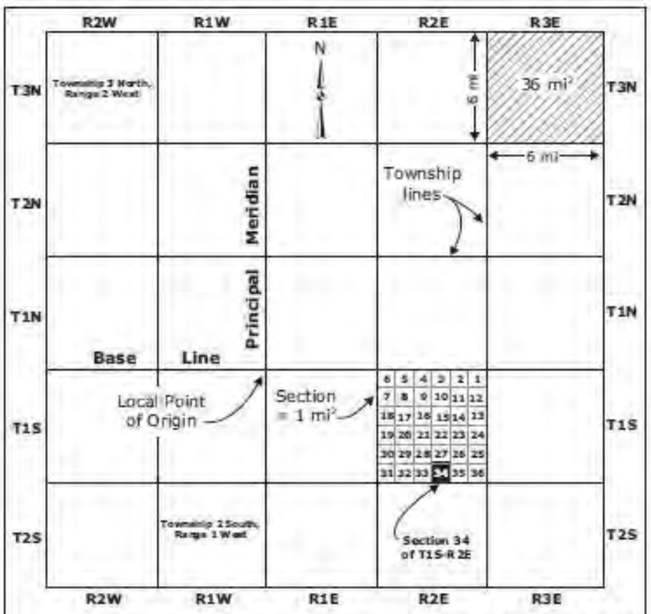
1. expose the top 1 meter of soil
2. describe the exposed soil profile
3. take samples of each soil horizon
4. prepare soil samples for lab analyses
5. analyze the soil samples in the lab
6. review the data to understand your soil better
7. Use from SCS-SOILS-232 to record results

Record Site Information:

A soil description is not as useful if the location or site information for the description is not recorded. This allows other people to go back to the site to gather additional information that was not collected the first time. It also puts the information into context so that it can be compared to other soil descriptions from similar locations. If two descriptions were taken from the same place on the landscape where the same parent materials created similar soils, they will most likely have similar characteristics. By knowing where a soil description came from you can predict where to find other places with the same soil.

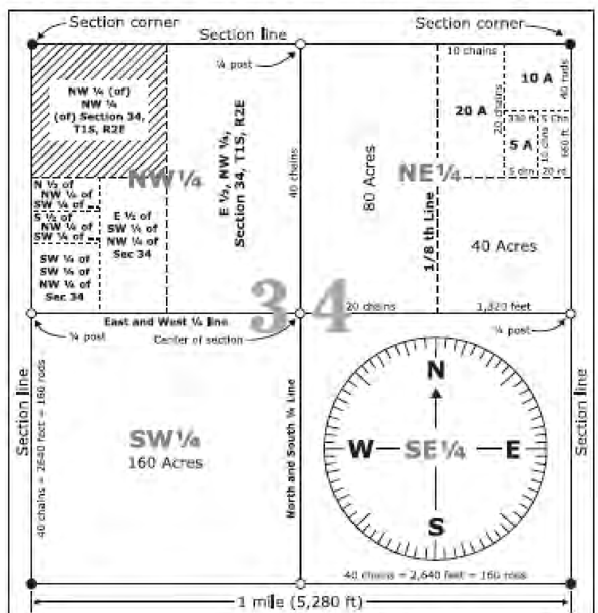
1. Use a map to help you record the location using the information below. Find the Township, Range, and section on a map or coordinate system. Record your location using this convention:____feet east and _____feet north of the SW corner of sec. 5, T. 41 N., R 5 E. So beginning from the southwest corner of the section you are in your pit is ____feet east and ___ feet north of the southwest corner of section 5 in Township 41 North, Range 5 East. You can also add GPS coordinates.
2. Next record the parent material. If you do not know this you can find a report in WebSoilSurvey that will have this information.
3. Measure or estimate the slope of your site (use a clinometer or Abney level).
4. Use a compass to find the aspect or compass direction of the slope.
5. Use the following guides to determine your landscape position, geomorphic component, slope shape, and hillslope component.

TOWNSHIPS and RANGES—Each township is identified using two indexes: 1) **Township or Tier** (north-south number relative to the base line), and 2) **Range** (east-west number relative to the Principal Meridian). For example, a township is described as T2N, R4E for second township row north of the base line and fourth range row east of the prime meridian.



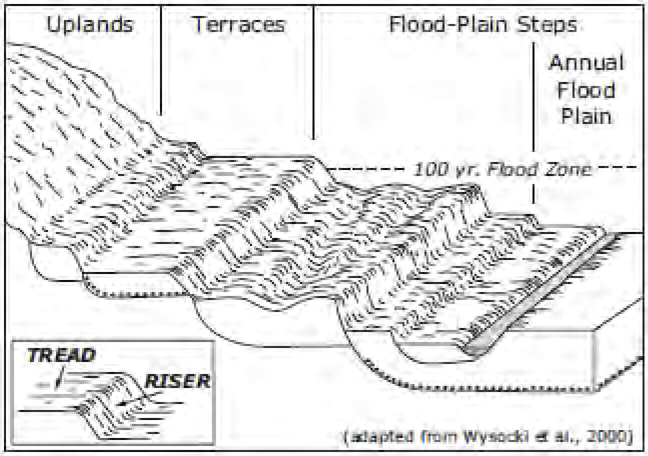
(Modified from Mozola, 1989)

SECTIONS—Each 1-square-mile **section** is numbered sequentially starting with 1 in the northeast corner of a township proceeding in east-west rows, wrapping back and forth to fill in the township; e.g., *Section 34, T1S, R2E* (Section 34 of Township 1 South, Range 2 East).

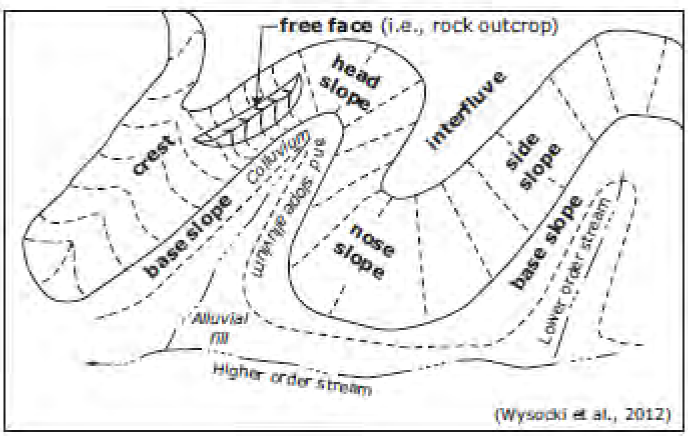


(Modified from Mozola, 1989)

SECTION SUBDIVISIONS—The PLSS subdivides sections into half- and quarter-sections. The section area fraction (1/2, 1/4) is combined with the compass quadrant that the area occupies in a section; e.g., *SW 1/4, Section 34, T1S, R2E* (southwest quarter of section 34, township 1 south, range 2 east). Additional subdivisions, by halves and quarters, describe progressively smaller areas. The land description is presented consecutively beginning with the smallest subdivision; e.g., a 20-acre parcel described as *N 1/2, NW 1/4, SW 1/4, NW 1/4 of Section 34, T1S, R2E* (north half of the northwest quarter of the southwest quarter of the northwest quarter of section 34, township 1 south, range 2 east).



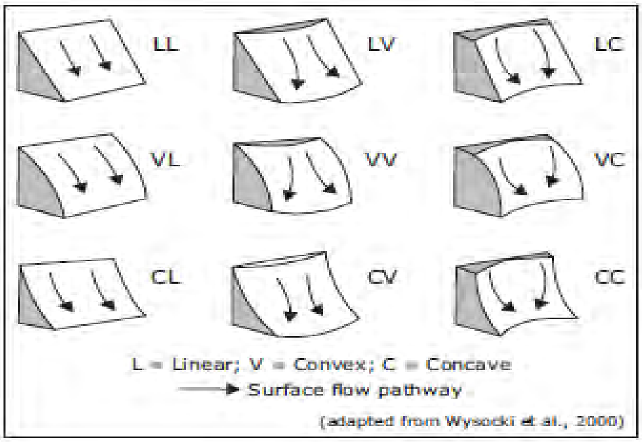
Landscape poition:



Geomorphic Component:

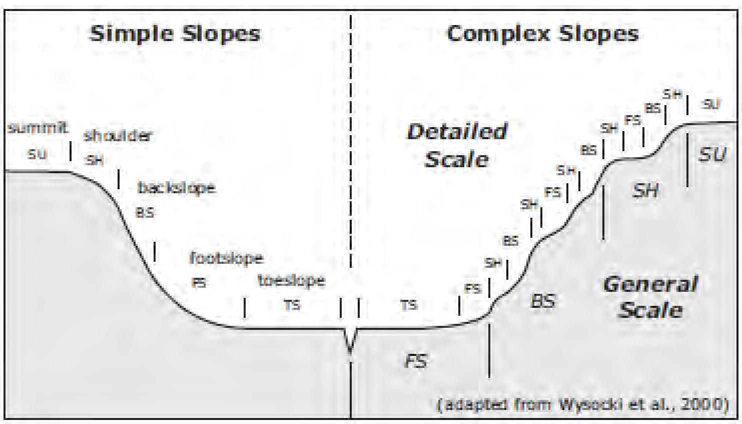
Slope Shape

Down Slope (Vertical)	Across Slope (Horizontal)	Code
concave	concave	CC
concave	convex	CV
concave	linear	CL
convex	concave	VC
convex	convex	VV
convex	linear	VL
linear	concave	LC
linear	convex	LV
linear	linear	LL



(adapted from Wysocki et al., 2000)

Hillslope Component: ____________



(adapted from Wysocki et al., 2000)

Field measurements are done once at each site

Three replicate samples from each horizon are taken and reported one time for each site.

Soil Pit Technique:

First, obtain permission to dig a pit. Obey any and all safety precautions requested, and ask about power and water lines.

1. Starting from top, observe profile to determine properties and differences between horizons.
2. Place golf tee or marker at the top and bottom of each horizon to clearly identify it.
3. Look for: different colors, shapes, roots, the size and amount of stones, small dark nodules (called concretions), worms, or other small animals and insects, worm channels, and anything else that is noticeable.
4. First, obtain permission to take samples from the road cut, excavation, or other soil profile exposed by others. Obey any and all safety precautions requested. Ask about power and water lines.

Auger Technique:

1. Identify an area where you can dig four holes where the soil profiles should be similar.
2. Spread a plastic bag, tarp, board, or other surface on the ground next to where you will dig your first hole.
3. Assemble a profile of the top 1 meter of the soil by removing successive samples with the auger and laying them end-to-end as follows:
4. Identify each horizon and measure its thickness using the depth of the auger hole.

Surface Sample Technique:

In situations where it is not possible to expose the top meter of soil, another option is to use the top 10 cm of soil as a horizon sample for soil characterization.

1. Use a garden trowel or shovel to carefully remove the top 10 cm of soil from a small area and set it on the ground.
2. Treat this sample as a horizon and proceed to characterize its properties.

Designations for Horizons and Other Layers

As soil formation proceeds, horizons may be detected in their early stages only by very careful examination. As age increases, horizons generally are more easily identified in the field. Only one or two different horizons may be readily apparent in some very old, deeply weathered soils in tropical areas where annual precipitation is high.

Layers of different kinds are identified by symbols. Designations are provided for layers that have been changed by soil formation and for those that have not. Each horizon designation indicates either that the original material has been changed in certain ways or that there has been little or no change. The designation is assigned after comparison of the observed properties of the layer with properties inferred for the material before it was affected by soil formation. The processes that have caused the change need not be known; properties of soils relative to those of an estimated parent material are the criteria for judgment. The parent material inferred for the horizon in question, not the material below the solum, is used as the basis of comparison. The inferred parent material commonly is very similar to, or the same as, the soil material below the solum.

Designations show the investigator's interpretations of genetic relationships among the layers within a soil. Layers need not be identified by symbols for a good description; yet, the usefulness of soil descriptions is greatly enhanced by the proper use of designations.

Designations are not substitutes for descriptions. If both designations and adequate descriptions of a soil are provided, the reader has the interpretation made by the person who described the soil and also the evidence on which the interpretation was based.

Genetic horizons are not equivalent to the diagnostic horizons of *Soil Taxonomy*. Designations of genetic horizons express a qualitative judgment about the kind of changes that are believed to have taken place. Diagnostic horizons are quantitatively defined features used to differentiate among taxa. Changes implied by genetic horizon designations may not be large enough to justify recognition of diagnostic criteria. For example, a designation of Bt does not always indicate an argillic horizon. Furthermore, the diagnostic horizons may not be coextensive with genetic horizons.

Three kinds of symbols are used in various combinations to designate horizons and layers. These are capital letters, lower case letters, and Arabic numerals. Capital letters are used to designate the master horizons and layers; lower case letters are used as suffixes to indicate specific characteristics of master horizons and layers; and Arabic numerals are used both as suffixes to indicate vertical subdivisions within a horizon or layer and as prefixes to indicate discontinuities.

Master Horizons and Layers

The capital letters O, A, E, B, C, and R represent the master horizons and layers of soils. The capital letters are the base symbols to which other characters are added to complete the designations. Most horizons and layers are given a single capital letter symbol; some require two.

O horizons or layers: *Layers dominated by organic material. Some are saturated with water for long periods or were once saturated but are now artificially drained; others have never been saturated.*

Some O layers consist of undecomposed or partially decomposed litter, such as leaves, needles, twigs, moss, and lichens, that has been deposited on the surface; they may be on top of either mineral or organic soils. Other O layers, are organic materials that were deposited under saturated conditions and have decomposed to varying stages (Soil Survey Staff, 1975). The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half of the weight. Some soils consist entirely of material designated as O horizons or layers.

An O layer may be on the surface of a mineral soil or at any depth beneath the surface, if it is buried. A horizon formed by illuviation of organic material into a mineral subsoil is not an O horizon, although some horizons that formed in this manner contain much organic matter.

A horizons: *Mineral horizons that formed at the surface or below an O horizon, that exhibit obliteration of all or much of the original rock structure, and that show one or more of the following: (1) an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons (defined below) or (2) properties resulting from cultivation, pasturing, or similar kinds of disturbance.*

If a surface horizon has properties of both A and E horizons but the feature emphasized is an accumulation of humified organic matter, it is designated an A horizon. In some places, as in warm arid climates, the undisturbed surface horizon is less dark than the adjacent underlying horizon and contains only small amounts of organic matter. It has a morphology distinct from the C layer, although the mineral fraction is unaltered or only slightly altered by weathering. Such a horizon is designated A because it is at the surface; however, recent alluvial or eolian deposits that retain rock structure[1] are not considered to be an A horizon unless cultivated.

E horizons: *Mineral horizons in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles. These horizons exhibit obliteration of all or much of the original rock structure.*

An E horizon is usually, but not necessarily, lighter in color than an underlying B horizon. In some soils the color is that of the sand and silt particles, but in many soils coatings of iron oxides or other compounds mask the color of the primary particles. An E horizon is most commonly differentiated from an overlying A horizon by its lighter color. It generally has less organic matter than the A horizon. An E horizon is most commonly differentiated from an underlying B horizon in the same sequum by color of higher value, by lower chroma or both, by coarser texture, or by a combination of these properties. An E horizon is commonly near the surface below an O or A horizon and above a B horizon, but the symbol E can be used for eluvial horizons within or between parts of the B horizon or for those that extend to depths greater than normal observation if the horizon has resulted from soil genesis.

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[1] Rock structure includes fine stratification in unconsolidated, or pseudomorphs, of weathered minerals that retain their positions relative to each other and to unweathered minerals in saprolite from consolidated rocks.

B horizons: *Horizons that formed below an A, E,, or O horizon and are dominated by obliteration of all or much of the original rock structure and show one or more of the following:*

(1) illuvial concentration of silicate clay, iron, aluminum, humus, carbonates, gypsum, or silica, alone or in combination;
(2) evidence of removal of carbonates;
(3) residual concentration of sesquioxides;
(4) coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chroma, or redder in hue than overlying and underlying horizons without apparent illuviation of iron;
(5) alteration that forms silicate clay or liberates oxides or both and that forms granular, blocky, or prismatic structure if volume changes accompany changes in moisture content; or
(6) *brittleness.*

All kinds of B horizons are subsurface horizons or were originally. Included as B horizons where contiguous to another genetic horizon are layers of illuvial concentration of carbonates, gypsum, or silica that are the result of pedogenic processes (these layers may or may not be cemented) and brittle layers that have other evidence of alteration, such as prismatic structure or illuvial accumulation of clay.

C horizons or layers: *Horizons or layers, excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons. The material of C layers may be either like or unlike that from which the solum presumably formed. The C horizon may have been modified even if there is no evidence of pedogenesis.*

Included as C layers are sediment, saprolite, unconsolidated bedrock, and other geologic materials that commonly are uncemented (table 3-14) and exhibit low or moderate excavation difficulty (table 3-21). Some soils form in material that is already highly weathered. If such material does not meet the requirements of A, E, or B horizons, it is designated C. Changes not considered pedogenic are those not related to overlying horizons. Layers that have accumulations of silica, carbonates, or gypsum or more soluble salts are included in C horizons, even if indurated (table 3-14). If the indurated layers are obviously affected by pedogenic processes, they are a B horizon.

R layers: *Hard Bedrock*

Granite, basalt, quartzite and indurated limestone or sandstone are examples of bedrock that are designated R. These layers are cemented and excavation difficulty exceeds moderate. The R layer is sufficiently coherent when moist to make hand digging with a spade impractical, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may contain cracks that generally are too few and too small to allow roots to penetrate at intervals of less than 10 cm. The cracks may be coated or filled with clay or other material.

Soil Color

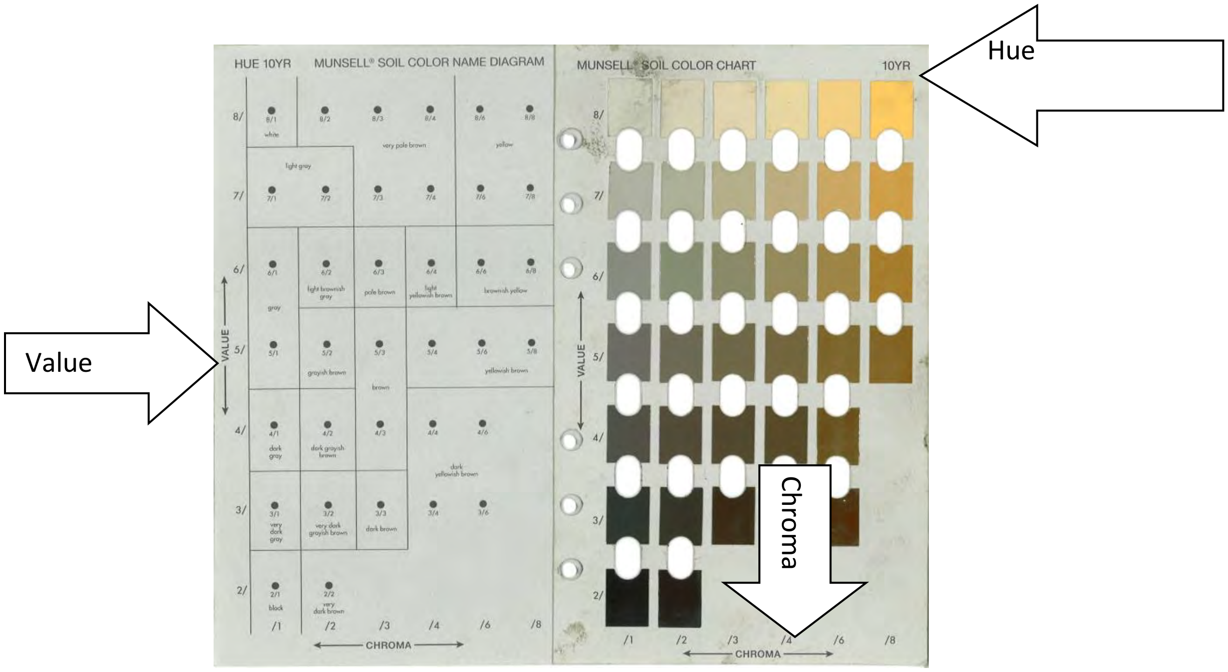
Elements of soil color descriptions are:

1. color name
2. Munsell notation
3. water state
4. physical state:
    a. example "brown (10YR 5/3), dry, crushed, and smoothed."

Physical state is recorded as broken, rubbed, crushed, or crushed and smoothed. The term "crushed" usually applies to dry samples and "rubbed" to moist samples. If unspecified, the surface is broken. The color of the soil is recorded for a surface broken through a ped if a ped can be broken as a unit.

The color value of most soil material becomes lower after moistening. Consequently, the water state of a sample is always given. The water state is either "moist" or "dry." The dry state for color determinations is air-dry and should be made at the point where the color does not change with additional drying. Color in the moist state is determined on moderately moist or very moist soil material and should be made at the point where the color does not change with additional moistening. The soil should not be moistened to the extent that glistening takes place as color determinations of wet soil may be in error because of the light reflection of water films. In a humid region, the moist state generally is considered standard; in an arid region, the dry state is standard. In detailed descriptions, colors of both dry and moist soil are recorded if feasible. The color for the regionally standard moisture state is usually described first. Both moist and dry colors are particularly valuable for the immediate surface and tilled horizons in order to assess reflectance.

Munsell notation is obtained by comparison with a Munsell system color chart. The most commonly used chart includes only about one fifth of the entire range of hues[9]. It consists of about 250 different colored papers, or chips, systematically arranged on hue cards according to their Munsell notations. Figure 3-24 illustrates the arrangements of color chips on a Munsell color card.



The Munsell color system uses three elements of color—*hue, value*, and *chroma*—to make up a color notation. The notation is recorded in the form: hue, value/chroma—for example, 5Y 6/3.

Hue is a measure of the chromatic composition of light that reaches the eye. The Munsell system is based on five principal hues: red (R), yellow (Y), green (G), blue (B), and purple (P). Five intermediate hues representing midpoints between each pair of principal hues complete the 10 major hue names used to describe the notation. The intermediate hues are yellow-red (YR), green-yellow (GY), blue-green (BG), purple-blue (PB), and red-purple (RP). The relationships among the 10 hues are shown in figure 3-25. Each of the 10 major hues is divided into four segments of equal visual steps, which are designated by numerical values applied as prefixes to the symbol for the hue name[10]. In figure 3-25, for example, 10R marks a limit of red hue. Four equally spaced steps of the adjacent yellow-red (YR) hue are identified as 2.5YR, 5YR, 7.5YR, and 10YR respectively. The standard chart for soil has separate hue cards from 10R through 5Y.

Value indicates the degree of lightness or darkness of a color in relation to a neutral gray scale. On a neutral gray (achromatic) scale, value extends from pure black (0/) to pure white (10/). The value notation is a measure of the amount of light that reaches the eye under standard lighting conditions. Gray is perceived as about halfway between black and white and has a value notation of 5/. The actual amount of light that reaches the eye is related logarithmically to color value. Lighter colors are indicated by numbers between 5/

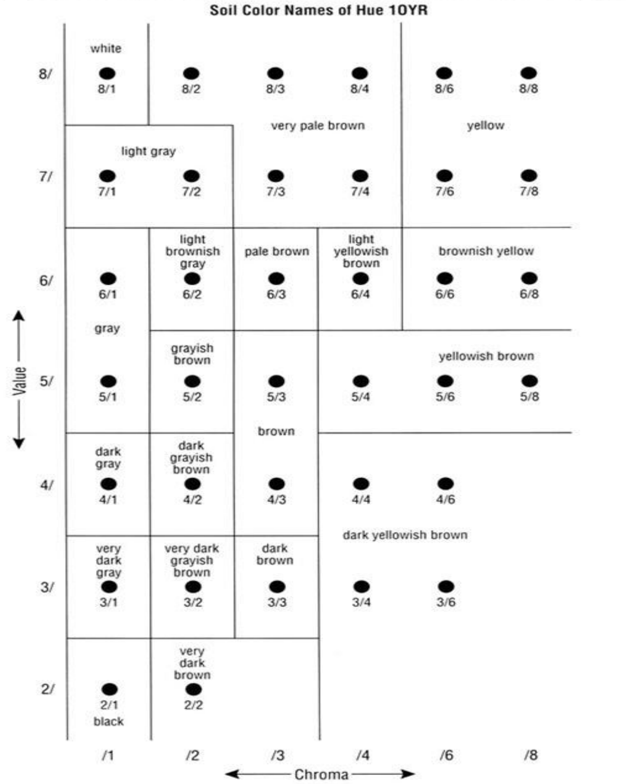
and 10/; darker colors are indicated by numbers from 5/ to 0/. These values may be designated for either achromatic or chromatic conditions. Thus, a card of the color chart for soil has a series of chips arranged vertically to show equal steps from the lightest to the darkest shades of that hue. Figure 3-24 shows this arrangement vertically on the card for the hue of 10YR.

Chroma is the relative purity or strength of the spectral color. Chroma indicates the degree of saturation of neutral gray by the spectral color. The scales of chroma for soils extend from /0 for neutral colors to a chroma of /8 as the strongest expression of color used for soils. Figure 3-24 illustrates that color chips are arranged horizontally by increasing chroma from left to right on the color card.

The complete color notation can be visualized from figure 3-24. Pale brown, for example, is designated 10YR 6/3. Very dark brown is designated 10YR 2/2. All of the colors on the chart have hue of 10YR. The darkest shades of that hue are at the bottom of the card and the lightest shades are at the top. The weakest expression of chroma (the grayest color) is at the left; the strongest expression of chroma is at the right.

FIGURE 3-24

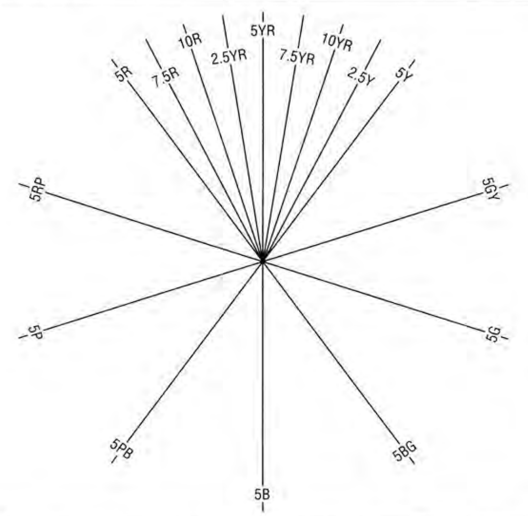
Soil Color Names of Hue 10YR



The arrangement of color chips according to value and chroma on the soil-color card of 10YR hue.

At the extreme left of the card are symbols such as N 6/. These are colors of zero chroma which are totally achromatic—neutral color. They have no hue and no chroma but range in value from black (N 2/) to white (N 8/). An example of a notation for a neutral (achromatic) color is N 5/ (gray). The color 10YR 5/1 is also called "gray," for the hue is hardly perceptible at such low chroma.

FIGURE 3-25



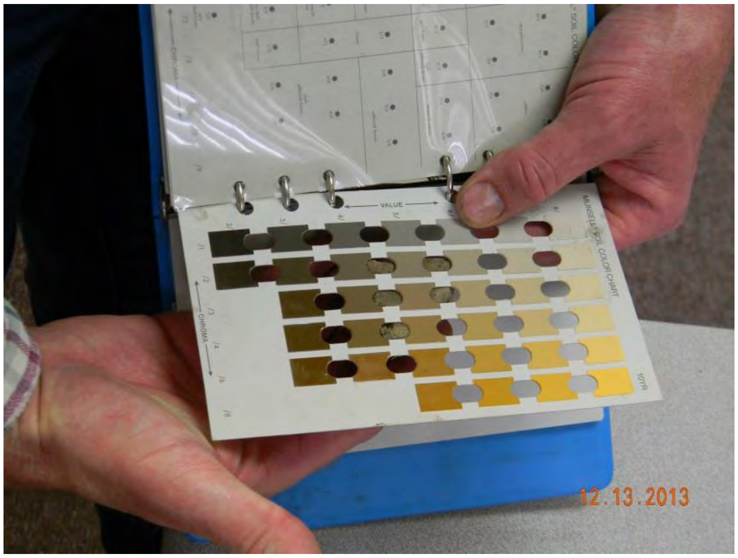
A schematic diagram of relationships among the five principal and five intermediate hues of the Munsell Color System and subdivisions within the part used for most soil colors.

Conditions for measuring color.—The quality and intensity of the light affect the amount and quality of the light reflected from the sample to the eye. The moisture content of the sample and the roughness of its surface affect the light reflected. The visual impression of color from the standard color chips is accurate <u>only under standard conditions</u> of light intensity and quality. Color determination may be inaccurate early in the morning or late in the evening. When the sun is low in the sky or the atmosphere is smoky, the light reaching the sample and the light reflected is redder. Even though the same kind of light reaches the color standard and the sample, the reading of sample color at these times is commonly one or more intervals of hue redder than at midday. Colors also appear different in the subdued light of a cloudy day than in bright sunlight. If artificial light is used, as for color determinations in an office, the light source used must be as near the white light of midday as possible. With practice, compensation can be made for the differences unless the light is so subdued that the distinctions between color chips are not apparent. The intensity of incidental light is especially critical when matching soil to chips of low chroma and low value.

Roughness of the reflecting surface affects the amount of reflected light, especially if the incidental light falls at an acute angle. The incidental light should be as nearly as possible at a right angle. For crushed samples, the surface is smoothed; the state is recorded as "dry, crushed, and smoothed."

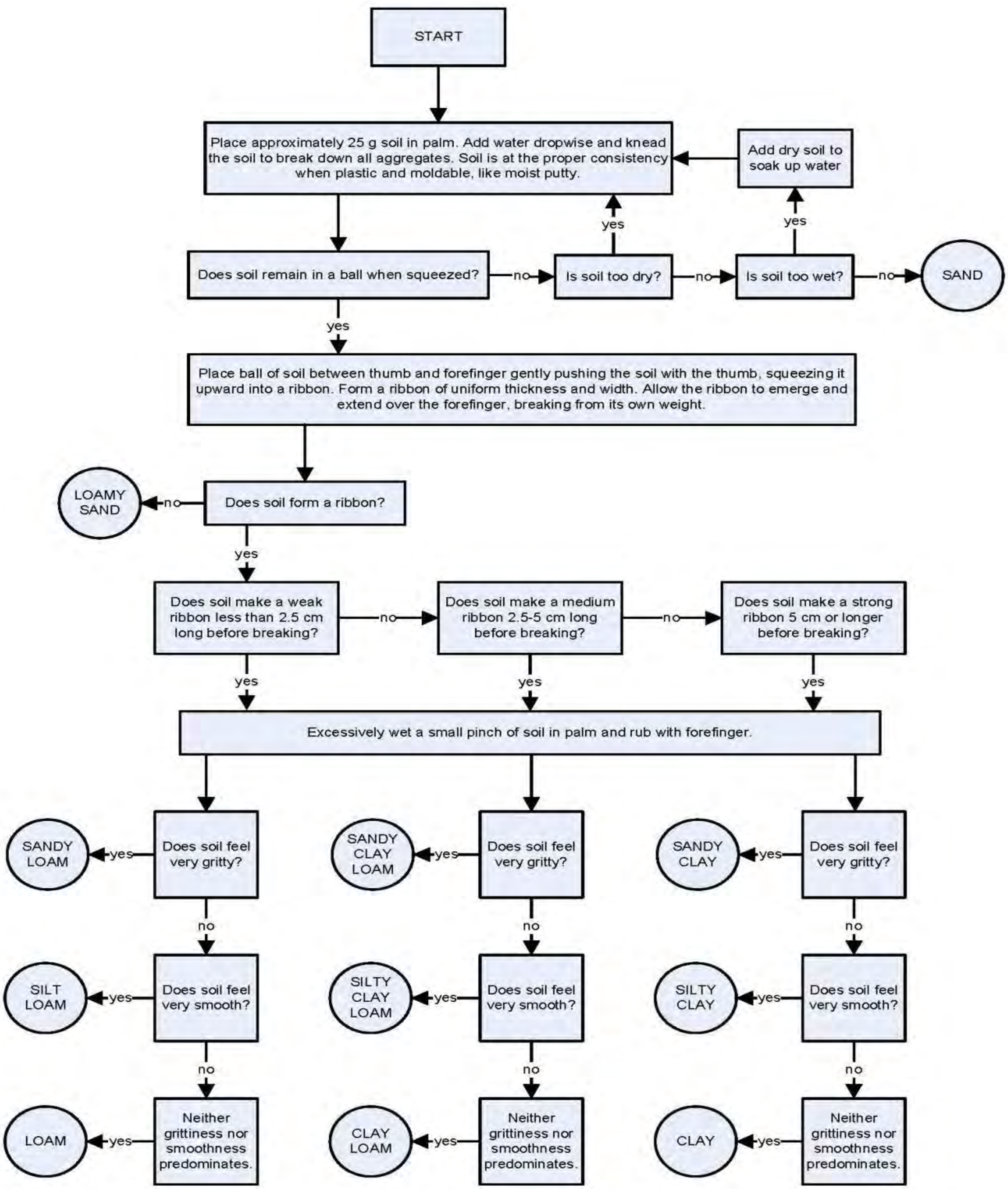
To measure the color of a soil sample. - Use the following procedure:

1. Place a dry sample in the palm of your hand (this may be a finely ground sample, or a soil aggregate).
2. With your light source behind you (light shining over your shoulder),
3. choose a page from the Munsell color book that is close to the color of your sample.
4. Holding the <u>color page over the sample</u>, move the page around to view your sample through the holes in the page.
5. Find the closest match.
6. When you have found a close match, determine if your sample may be redder or yellower than the color chip you have chosen; if you think it may be, go one page to the front of the book (for red) or to the back of the book (for yellow) and look at the chip with the same value and chroma. Is this a better match?



Guide to Texture by Feel

Modified from S.J. Thien. 1979. *A flow diagram for teaching texture by feel analysis.* Journal of Agronomic Education. 8:54-55.



TEXTURE CLASS—

Texture Class or Subclass	Code	
	Conv.	NASIS
Coarse Sand	cos	
Sand	s	S
	fs	
	vfs	
Loamy Coarse Sand	lcos	
Loamy Sand	ls	LS
	lfs	
	lvfs	LVFS
Coarse Sandy Loam	cosl	COSL
Sandy Loam	sl	SL
Fine Sandy Loam	fsl	FSL
Very Fine Sandy Loam	vfsl	VFSL
Loam	l	L
Silt Loam	sil	SIL
Silt	si	SI
Sandy Clay Loam	scl	SCL
Clay Loam	cl	CL
Silty Clay Loam	sicl	SICL
Sandy Clay	sc	SC
Silty Clay	sic	SIC
Clay	c	C

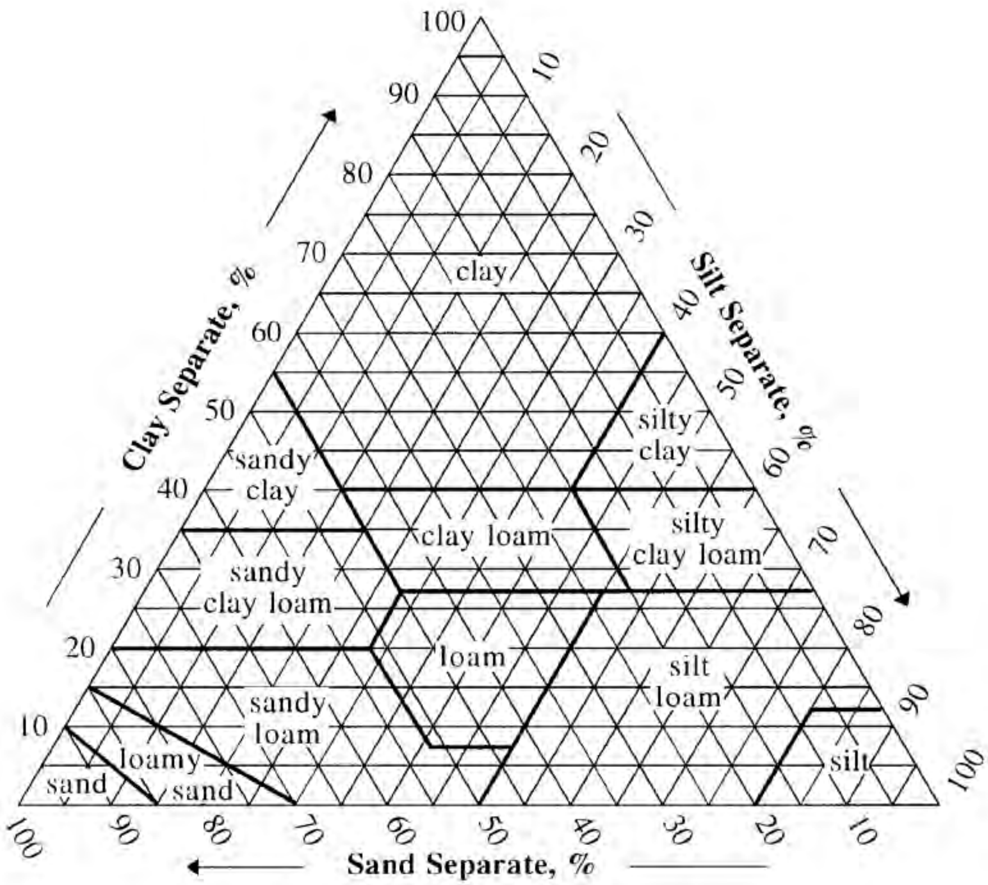
Texture class can be determined fairly well in the field by feeling the sand particles and estimating silt and clay content by flexibility and stickiness. There is no field mechanical-analysis procedure that is as accurate as the fingers of an experienced scientist, especially if standard samples are available. A person must be familiar with the composition of the local soils. This is because certain characteristics of soils can create incorrect results if the person does not take these characteristics into account.

In some environments clay aggregates form that are so strongly cemented together that they feel like fine sand or silt. In humid climates iron oxide is the cement. In desert climates silica is the cement and in arid regions lime can be the cement. It takes prolonged rubbing to show that they are clays and not silt loams.

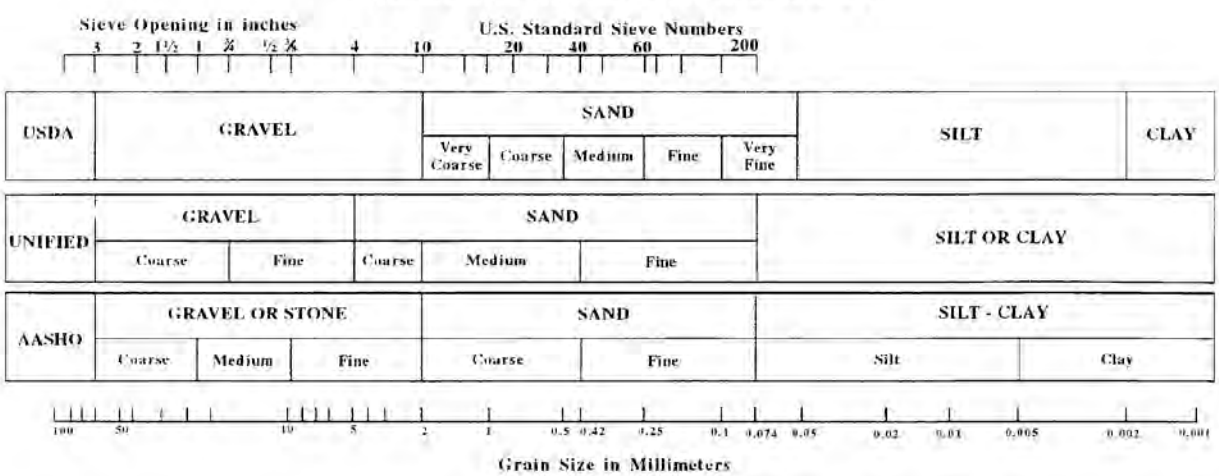
Some soils derived from granite contain grains that resemble mica but are softer. Rubbing breaks down these grains and reveals that they are clay. These grains resist dispersion and field and laboratory determinations may disagree.

Many soil conditions and components mentions earlier cause inconsistencies between field texture estimates and standard laboratory data. These are, but not limited to, the presence of cements, large clay crystals, and mineral grains. If field and laboratory determinations are inconsistent, one or more of these conditions is suspected.

Soil Textural Triangle

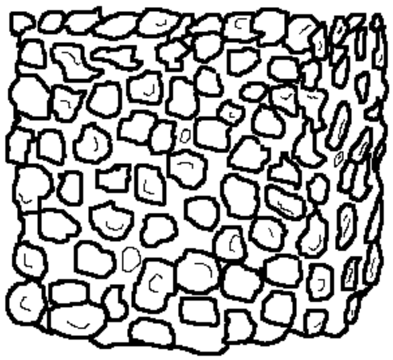
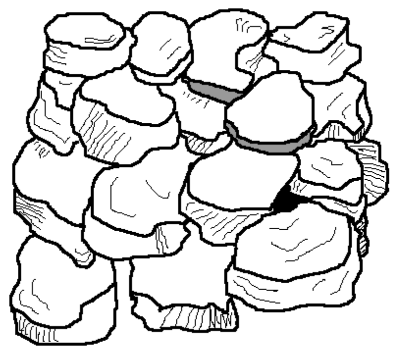
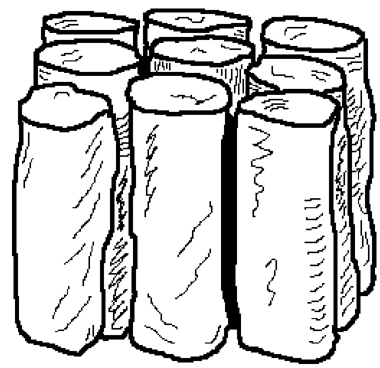
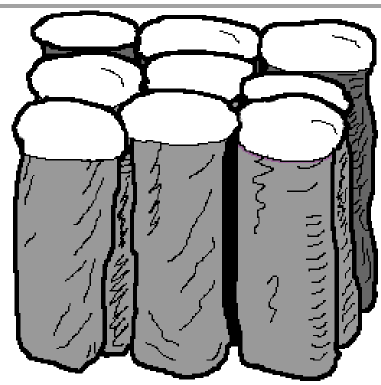
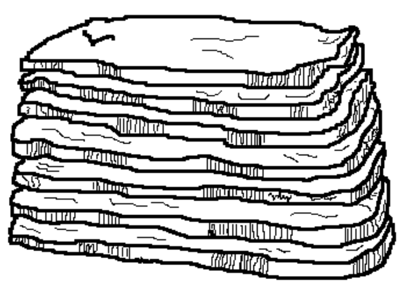
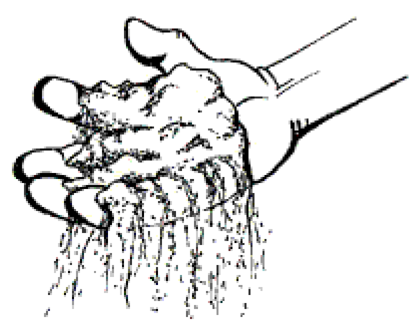


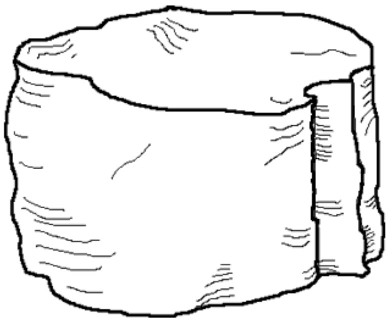
COMPARISON OF PARTICLE SIZE SCALES



To determine Soil Structure:

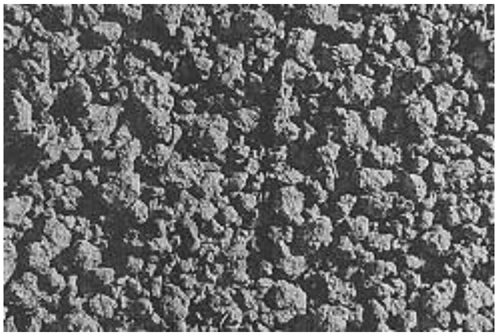
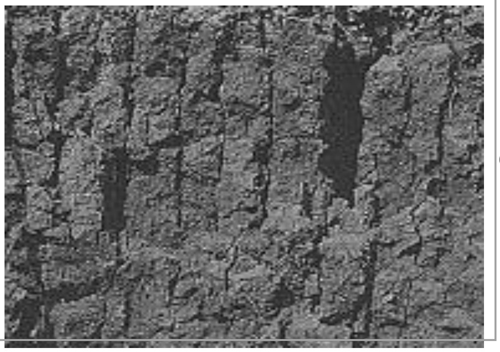
Soil structure is the shape that the soil takes based on its physical and chemical properties. Each individual unit of soil structure is called a **ped**. Take a sample of undisturbed soil in your hand (either from the pit or from the shovel or auger). Look closely at the soil in your hand and examine its structure. Possible choices of soil structure are:

		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil but also seen in E horizons.	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

	
Massive: Soil has no visible structure, is hard to break apart and appears in very large clods.	

Below are some images of the different soil structures.

With Structure:

Granular		**Blocky**	
Prismatic		**Columnar**	

Platy	

Structureless:

Single grained		**Massive**	

To determine Soil Consistence:

Take a ped from the top soil horizon. If the soil is very dry, moisten the face of the profile using a water bottle with a squirt top and then remove a ped to determine consistence.

(Repeat this procedure for each horizon in your profile.)

Holding it between your thumb and forefinger, gently squeeze the ped until it pops or falls apart. Record one of the following categories of soil consistence on the data sheet.

Loose

You have trouble picking out a single ped and the structure falls apart before you handle it.*

* Soils with "single grained" structure always have loose consistence.

Friable

The ped breaks with a small amount of pressure.

Firm

The ped breaks when you apply a good amount of pressure and dents your fingers before it breaks.

Extremely Firm

The ped can't be crushed with your fingers (you need a hammer!).

SCS-SOILS-232G
REV. 12-70
FILE CODE SOILS-11

SOIL DESCRIPTION

U.S. DEPARTMENT OF AGRICULTURE
~~SOIL CONSERVATION SERVICE~~
Natural Resources Conservation Service

Soil type | File No.

Area | Date | Stop No.

Classification

Location

N. veg. (or crop) | Climate

Parent material

Physiography

Relief | Drainage | Salt or alkali

Elevation | Gr. water | Stoniness

Slope | Moisture

Aspect | Root distrib. | % Clay *

Erosion | % Coarse fragments * | % Coarser than V.F.S. *

Permeability

Additional notes

Landscape position: Upland - Terrace - Floodplain - other - ______________

Geomorphic Component:

Slope Shape:

Hillslope Component:

Described by:

* Control section average

Horizon	Depth	Color		Texture	Structure	Consistence			Reaction	Boundary				
		Dry	Moist			Dry	Moist	Wet						