Why classify Soil?

- To organize our knowledge about soils
- To deal with complexity
- To develop principles and guidelines for proper use and management:
    a. to predict behavior
    b. to identify best uses
    c. to estimate productivity
    d. to identify potential problems
- To facilitate easier transfer of information and technology
- To provide a basis for research and experimentation
- To understand relationships among individuals of the population
- To provide an organizational chart or map of the world of soils as we perceive it - the soil survey

Basic principles of classification

- Classification is the grouping of objects into classes or groups on the basis of similarities or differences in their common properties.
- Individual objects make up a population.
- A class is a group of individual or other classes similar in selected properties and distinguished from all other classes of the same population by differences in these properties.
- In any system of classification, those groups about which the greatest number of things can be stated for the chosen objective are generally the best and the most useful classification groupings.

Key concepts of classification

• Types of objects

- Individuals
- Populations
- Sub-populations (strata)

• Issues regarding classes

- Existence of **modal** (‘typical’) individuals
- Measures of **similarity** in **state space**
- Measures of **compactness** of classes

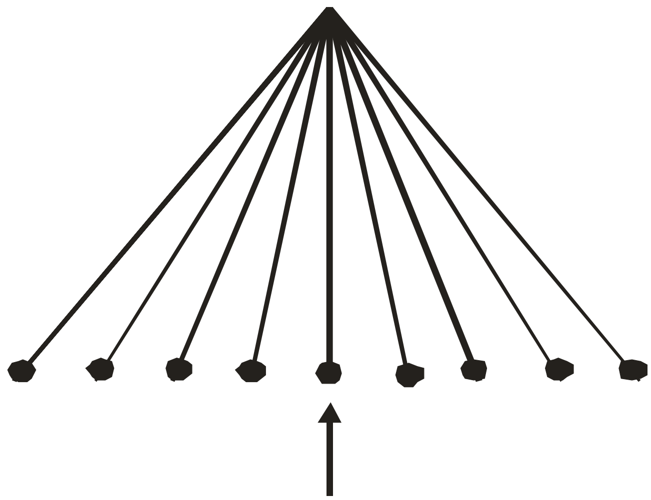
• Types of characteristics

- **Differentiating**: used to defined classes
- **Accessory**: consistently associated with a class;
- **co-variant** with differentiating characteristics

Accidental: not associated with the classes

Attributes of a good differentiating characteristics

- ❑ Is important for the objective of classification
- ❑ Carry the greatest possible co-varying or accessory characteristics that are also important for the objective of classification.



Principles of differentiation as they affect classes

- ❖ A differentiating characteristic must be important for the objective.
- ❖ A differentiating characteristic must be a property of the things classified or a direct interpretation for the objective.
- ❖ The differentiating characteristics should carry as many accessory properties as possible for the objective.
- ❖ The class interval of a differentiating characteristic must provide classes homogenous for the objective.

Principles of differentiation as they affect relationship among categories

- ➢ Differentiating characteristics must classify all individuals in any single population (Nikiforrof principle of wholeness of taxonomic categories).
- ➢ Greatly different “kingdoms” require different differentiating characteristics at the same level of abstraction.

- All classes of the same category of a single population should be based on the same characteristic.
- A differentiating characteristic in one category must not separate like things in a lower category.

What is different about soils?

- There is really no soil '**individual**' as a self-standing object.
- The emphasis in soil is on defining **mappable** classes

Rather than on optimal classification of individuals.

- There is no true **inheritance** or genetics as it is understood in biology

Concept of the pedon as a discrete object within the soil continuum (Soil individuals)

- The major difficulty in defining soil individuals or basic entities follows from the existence of soil as a continuum.
- The term **pedon** has been proposed as a collective noun for a small basic soil unit that can be regarded as the basic soil entities or soil individual.
- A pedon consists of a small volume of soil which includes the full solum and the upper part of the unconsolidated Parent material. It is usually less than two metres (2m) in depth, and has a lateral cross-section that is roughly circular or hexagonal in shape and between $1m^2$ and $10m^2$ in area.

Source of criteria for soil classification.

- Different classification system uses different criteria
- For most part, the criteria used to classify soil are those that can be observed or determined rapidly by simple tests on the field.

Marbut (1932) proposed the following properties for differentiating soils at the level of soil type:-

- ❑ Number of horizons in the profile
- ❑ Colour of various horizons with special emphasis on the surface one or two
- ❑ Texture of each horizon
- ❑ Structure of the horizons
- ❑ Relative arrangement of horizons
- ❑ Thickness of horizons
- ❑ Thickness of the true soil (profile) Chemical composition of horizons
- ❑ Character of the soil material [alluvial, loess, sand]
- ❑ Geology of the soil material [parent material]

In addition to the above the USDA make use of:

- ❖ Soil Moisture Regimes
- ❖ Soil Temperature Regimes

Attributes of a good soil taxonomic system:

- ❖ Definition of a class or taxon should carry as nearly as possible the same meaning to each user
- ▪ Should be a multi-categoric system (hierarchical)
- ▪ lower levels - narrowly defined - large number of differentiating characteristics
- ▪ higher levels - broadly defined - few soil properties are used to differentiate
- ❖ Classes or taxa should be concepts of real bodies of soil that exist in nature
- ❖ Must be capable of providing for all the soils observed in a landscape

- ❖ Differentiating characteristics should be properties that are observable in the field or quantitatively measured by reliable techniques
- ❖ The system should be capable of modification to incorporate new knowledge with a minimum of disturbance
- ❖ The criteria used should keep undisturbed and cultivated soils in the same taxa.

Major ways of classifying soils

There are various ways to organize a soil classification. A major distinction is between **natural** and **technical** approaches:

Natural soil classifications group soils by some intrinsic property, behaviour, or genesis of the soils themselves, without reference to use.

• **Technical** soil classifications group soils by some properties or functions that relate directly to a proposed use or group of uses.

Natural classifications:

• Group by **ecologic region**, e.g. “prarie soils”, “boreal soils”. Geographically-compact but may have diverse properties and function.

•Group by **presumed genesis**, i.e. the development pathway of the soil profile. These are called **genetic** soil classifications. The soil individual is considered as a natural body with its own history and ecology. This depends on the interpretation of landscape and soil genesis.

Group by **similar properties**, working **bottom-up** from a set of individuals, to a set of classes, and then grouping the classes into super-classes. This can be done by:

– Subjective judgment of the classifier

– Numerical classification, usually multivariate

Technical classifications:

• *Land* Suitability Evaluation (FAO)

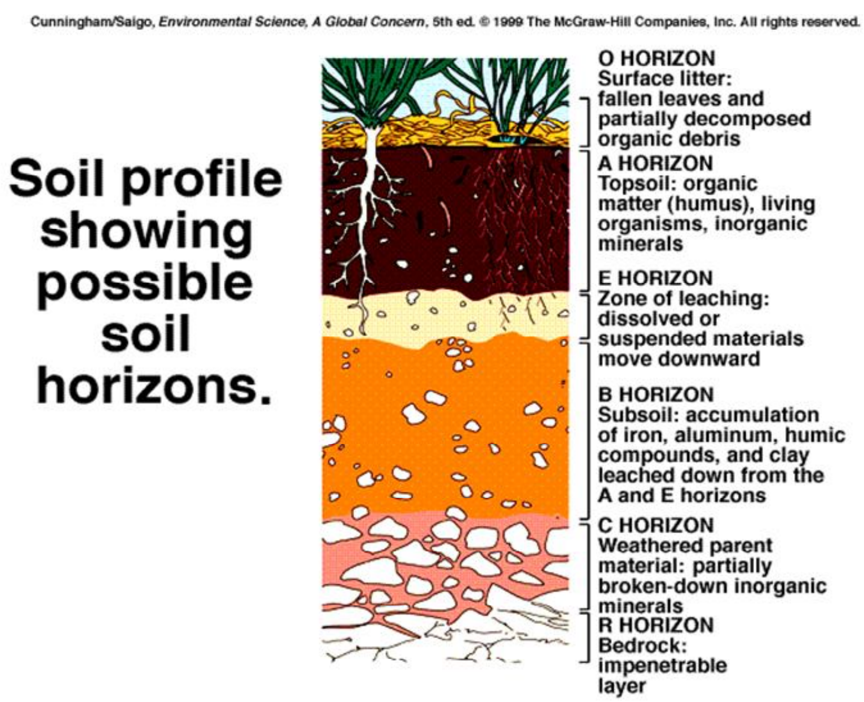
• Land Capability Classification(USDA)

• Fertility Capability Classification (FCC)

• Engineering group

• Hydrologic response

SOIL PROFILE AND HORIZONS: A Source of criteria for soil classification.



MASTER HORIZONS

Horizontal layers of soil called horizons can be described by their different morphological characteristics. Capital letters designate master horizons, which are further subdivided by Arabic numerals.

O Horizon

O horizon is an organic horizon. It is a surface layer characterized by accumulation of organic matter which may be dominated by partially decomposed or undecomposed organic material.

A Horizon

The A horizon is the uppermost mineral layer. It may lie below the O horizon. An A horizon has a high concentration of humus and it is usually regarded as an elluvial surface horizon.

E Horizon

The E horizon is an elluvial surface horizon. It has experience the loss of clay, organic matter, iron and aluminum oxides with the resultant accumulation of quartz and other resistant minerals. It is also characterized by bleached appearance because of loss of materials.

B Horizon

The B horizon is a subsurface mineral horizon showing evidence of illuvial accumulation of silicate clay, iron, aluminum, gypsum, or silica; carbonate removal; residual concentration of sesquioxides and silicate clay; coating of sesquioxides, (etc.).

C Horizon

The C horizon is a layer of minimal alteration. Material may be similar to or unlike that from which the other horizons formed.

R Layer

An R layer refers to hard consolidated bedrock. The R layer is presumed to be the material from which the overlying horizons are developed. But if it is a different material from that of the overlying mantle, it is represented by IIR, indicating what is called ***Lithological Discountinuity***.

TRANSITIONAL HORIZONS

Transitional horizons are dominated by properties of one master horizon but have the subordinate properties of another. These are designated by two capital letters, for example, AB, EB, BE, or BC. The first letter represents the dominant horizon characteristics.

SUBORDINATE DISTINCTIONS

Master horizons are further divided by subordinate characteristics, which usually do not apply to transitional horizons. Subordinate distinctions are identified by lower-case letters, called suffix symbols.

- ***a.*** *Highly decomposed organic material.* ***b****. Buried genetic horizon.* ***c.*** *Concretions or nodules.* ***d****. Physical root restriction.* ***e.*** *Organic material of intermediate composition.* ***f.*** *Frozen soil.* ***g****. Strong gleying.* ***h****.* I*lluvial accumulation of organic matter.* ***i****. Slightly decomposed organic matter.* ***k****. accumulation of carbonates.* ***m****. cementation or induration, km* . Cementation by carbonates; *qm* . Cementation by silica; *sm*. Cementation by iron; *ym*. Cementation by gypsum; *kqm*. Cementation by lime and silica; and *zm*. Cementation by salts more soluble than gypsum. ***n****. Accumulation of sodium.* ***o****. Residual accumulation of sesquioxides* ***p****. Tillage or other disturbance.* ***q****. Accumulation of silica.* ***r****. Weathered or soft bedrock.* ***s****. illuvial accumulation of sesquioxides and organic matter.* **ss** *. Presence of slickensides* ***t*** *. Accumulation of silicate clay* ***v*** *. plinthite.* ***w****. development of color or structure.* ***x****. fragipan character.* ***y****. Accumulation of gypsum* **z** *. accumulation of salts more soluble than gypsum*

DIAGNOSTIC HORIZONS:

Master horizons describe a soil profile, while diagnostic horizons are used to classify soils. Whereas master horizons are based on appearance, diagnostic horizons are based on soil formation processes. There are two types of diagnostic horizons. These are surface (epipedon) and subsurface horizon (Endopedon).

EPIPEDONS

An epipedon is the surface, or uppermost soil horizon. They are not synonymous to the A horizon. They may be thinner than the A horizon, or include the E or part or the entire B horizon.

Histic epipedon

This organic horizon is water saturated long enough for reduced conditions to occur unless artificially drained. It is 40 to 60 cm thick and has a low bulk density often less than 1 g cm^3.

Mollic epipedon

This epipedon is a soft dark grassland soil. Its organic carbon content is 0.6 percent or more; its base saturation is 50 percent or more; It has a minimum thickness of 18 cmand contains less than 250 ppm P_2O_5.

Anthropic epipedon

While similar to the mollic epipedon, the anthropic epipedon contains greater than 250 ppm citric acid soluble P_2O_5 with or without a 50 percent base saturation.

Umbric epipedon

Mollic-like in thickness, organic carbon content, color, P_2O_5 content, consistence, and structure, this epipedon has less than 50 percent base saturation.

Ochric epipedon

Ochric epipedon is light in colour and low in organic matter and too thin to be any of the other five epipedons. Ochric epipedon is the most common epipedon in Nigerian soils.

Plaggen epipedon

This man-made horizon is 50 cm or more thick and has resulted from centuries of accumulation of sod, straw, and manure, for example. It commonly contains artifacts such as pottery and bricks.

DIAGNOSTIC SUBSURFACE HORIZONS

Diagnostic subsurface horizons can be categorized as weakly developed horizons, as horizons featuring an accumulation of clay, organic matter, or inorganic salts, as cemented horizons, or as strongly acidic horizons.

Agric

The agric horizon is an illuvial horizon that has formed under cultivation and contains significant amounts of illuvial silt, clay, and humus. It is usually formed after prolonged years of cultivation.

Albic

Albic (L. *albus*, white) materials are soil materials with a color that is largely determined by the color of primary sand and silt particles rather than by the color of their coatings.

Argillic (Bt)

An argillic horizon is normally a subsurface horizon with a significantly higher percentage of phyllosilicate clay than the overlying soil material. It shows evidence of clay illuviation.

Calcic

The calcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to a significant extent.

Cambic

This horizon shows some evidence of alterations but is very weakly developed between A and C horizons. The cambic horizon has less illuviation evidence than found in the argillic and spodic horizons.

Gypsic (By) accumulation of $CaSO_4$; 15 cm or more thick 5% or more calcium sulfate.

Glossic (B/E) consists of an eluvial part (E - albic) and an illuvial part (Bt - argillic, or Bto-kandic or Btn-natric) sometimes referred to as tounging

Kandic (Bto) - fine textured subsurface horizon that has evidence of clay translocation and is composed mostly of low activity clays (low CEC and ECEC). The CEC (by the 1N NH_4OAC method at pH=7) is 16 cmol(+) or less per kg of clay and the ECEC (by the basic cations displaced by ammonium plus KCl extractable aluminum methods) is 12 cmol(+) or less per kg of clay.

Natric (Btn) - meets all the requirements of the argillic horizon and, in addition, has: a. either prismatic or columnar structure b. either (1) an exchangeable sodium percentage of 15 percent or more or (2) a sodium adsorption ratio (SAR) of 13 or more.

Oxic (Bo) - highly weathered horizon that consists of oxides of iron and aluminum, 1:1 clays and resistant minerals such as quartz. It has a thickness of 30 cm or more; less than 10 percent weatherable minerals; low CEC (≤ 16 cmol(+) per kg of clay

Salic (Bz) soluble salt accumulation - salts more soluble than gypsum 15 cm or more thick EC _>_ 30dS/m in a 1:1 soil water extract

Spodic (Bs or Bhs) - illuvial accumulations of sesquioxides and/or organic matter composed of spodic materials.

Other Diagnostic Soil Features

Abrupt textural change. Ochric or Albic overlies an argillic considerable increase in clay over a short distance in the profile usually double the clay content within a vertical distance of 7.5 cm

Glacic - (Bf). Ice in the form of ice lenses or wedges.

Lamellae - (Bt or Bw). Number of clay-enriched layers separated by coarser textured layers illuvial horizon less than 7.5 cm thick horizontal bands contain an accumulation of oriented clay bridging sand grains lamellae occur in a vertical series of two or more; each lamellae has an overlying eluvial.

Lithologic discontinuity. (Numerical prefix; e.g. 2Bt1) change in parent material geologic process rather than pedogenic possibly indicated by abrupt textural change, contrasting particle sizes, stone lines, mineral composition or orientation of rocks.

Plinthite - (Bv). Humus poor, iron-rich, ironstone hardpan hardens irreversibly after being exposed to repeated wetting and drying in place begins as soft, red iron segregations (mottled appearance) due to oxidation.

Slickensides - (Bss). Polished or grooved clay surfaces produced by one soil mass sliding against another common in shrink-swell clays indicates vertic.

Densic contact - (Bd or Cd). Boundary between soil and underlying densic material (plow pan, glacial till, etc).

Lithic contact - (R). Boundary between soil and consolidated underlying material digging with hand tools is impractical.

Paralithic contact - (Cr). Boundary between soil and weathered bedrock underlying material can be dug with hand tools.

CLIMATOLOGICAL DATA: **A Source of criteria for soil classification.**

Soil Moisture Regimes

The term “soil moisture regime” refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year.

Classes of Soil Moisture Regimes

Aquic moisture regime. The aquic moisture regime is a reducing regime in a soil that is virtually free of dissolved oxygen because it is saturated by water.

Aridic and torric moisture regimes. These terms are used for the same moisture regime but in different categories of the taxonomy. In the aridic (torric) moisture regime, the moisture control section is dry in all parts for more than half of the cumulative days per year.

Udic moisture regime. The udic moisture regime is one in which the soil moisture control section is not dry in any part for as long as 90 cumulative days in normal years.

Ustic moisture regime. The ustic moisture regime is intermediate between the aridic regime and the udic regime. Its concept is one of moisture that is limited but is present at a time when conditions are suitable for plant growth.

Xeric moisture regime. The xeric moisture regime is the typical moisture regime in areas of Mediterranean climates, where winters are moist and cool and summers are warm and dry.