Soil Taxonomy

A Basic System of Soil Classification for Making and Interpreting Soil Surveys

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CHAPTER 6
The Categories of Soil Taxonomy

A category of soil taxonomy is a set of classes that is defined approximately at the same level of generalization or abstraction and that includes all soils. There are six categories in soil taxonomy. In order of decreasing rank and increasing number of differentiae and classes, the categories are order, suborder, great group, subgroup, family, and series.

In one sense, soil taxonomy is a sorting process. In the highest category, one sorts all kinds of soil into a small number of classes. The number of classes is small enough for one to comprehend and remember them and to understand the distinctions among them. The sorting must make distinctions that are meaningful for our purposes. When all soils are sorted into a very few classes, such as the 12 orders, each order is very heterogeneous with respect to properties that are not considered in the sorting and that are not accessory to the properties that are considered. For some purposes, however, the order level may provide sufficient information. As one continues to classify a soil at lower and lower levels of soil taxonomy, more information is conveyed about the soil. This method of conveying information is one of the advantages of a multicategoric classification system.

Reducing the heterogeneity requires another sorting in the next lower category, the suborder. Again, the sorting must be meaningful, but the sorting in one order may have little meaning in another order. In soil taxonomy there are 64 suborders, a number larger than can be remembered conveniently along with all the properties of the suborders. If we focus on the suborders of a single order, however, we have, at the most, seven suborders to understand and remember. Each of the suborders in an order has the properties common to the order plus the properties used for sorting into that suborder. In each of the 64 suborders, there is still great heterogeneity, so we must sort again to obtain, at the next lower level, a set of meaningful great groups. There are more than 300 great groups, more than one can remember. One need focus, however, on only one suborder at a time.

The sorting process continues in the remaining categories down to the soil series. The soils in any one series are nearly homogeneous in that their range of properties is small and can be readily understood. Collectively, the thousands of soil series are far beyond our powers of comprehension, but they can be sorted category by category, and one seldom needs to comprehend more than a few of them at any one time.

Orders

There are 12 orders. They are differentiated by the presence or absence of diagnostic horizons or features that reflect soil-forming processes. If the soils in a given taxon are thought to have had significantly different genesis, the intent has been to sort out the differences in the next lower category.

Soil properties are the consequences of a variety of processes acting on parent materials over time. Distinctions among orders aid in understanding soils and remembering them on a grand scale. The processes that occur in soils must be orderly in relation to the soil-forming factors, which are climate and living organisms acting on parent materials over time, as conditioned by relief. These factors, in turn, have geographic order. The features of the soil-forming processes are clearly visible, but the details of the processes can only be inferred. The distinctions made in classifying soils cannot be based on the processes themselves because new knowledge is certain to change our ideas about the processes, but the features of the processes are facts that can be observed and measured and used as a basis for distinctions. Thus, the distinctions between orders are based on the markers left by processes that experience indicates are dominant forces in shaping the character of the soil. In this framework, the lack of features or the zero degree also is a logical criterion.

The 12 orders and the major properties that differentiate them illustrate the nature of this category. Complete definitions are given later in this publication.

These orders are not the only possible orders in the taxonomy. In fact, two new orders, Andisols and Gelisols, have been established since the first edition of *Soil Taxonomy*. The hierarchy is flexible, and other *ad hoc* orders may be defined to emphasize properties not considered in the 12 orders. The method of defining *ad hoc* orders is described in connection with nomenclature later in this publication.

Alfisols

The soils in this order have markers of processes that translocate silicate clays without excessive depletion of bases and without dominance of the processes that lead to the formation of a mollic epipedon. The unique properties of Alfisols are a combination of an ochric or umbric epipedon, an argillic or natric horizon, a medium to high supply of bases in the soils, and water available to mesophytic plants for more than half the year or more than 3 consecutive months during a warm season. Because these soils have water and bases, they are, as a whole, intensively used.

Andisols

The unique property of Andisols is a dominance of short-range-order minerals or Al-humus complexes that result from weathering and mineral transformation with a minimum of translocation. The characteristics common to most Andisols include a high phosphorus retention, available water capacity, and cation-exchange capacity. Most Andisols formed in volcanic ejecta or volcaniclastic materials. Andisols can form in almost any environment, however, as long as suitable temperature and adequate moisture are available to permit weathering and the formation of short-range-order minerals. The soils can have any diagnostic epipedon or subsurface horizon as long as the unique property of Andisols is in 60 percent of the upper 60 cm of the soils, disregarding O horizons that have 25 percent or more organic carbon.

Prior to 1989, the soils now classified as Andisols were included with Inceptisols, mainly as Andepts and Andaquepts, which were discontinued with the acceptance of Andisols as an order in soil taxonomy.

Aridisols

The unique properties common to Aridisols are a combination of a lack of water available to mesophytic plants for very extended periods, one or more pedogenic horizons, a surface horizon or horizons not significantly darkened by humus, and absence of deep, wide cracks (see Vertisols) and andic soil properties (see Andisols). Aridisols have no available water during most of the time that the soils are warm enough for plant growth (warmer than 5 ^{o}C [41 ^{o}F]), and they never have water continuously available for as long as 90 days when the soil temperature is above 8 ^{o}C (47 ^{o}F).

Aridisols are primarily soils of arid areas. They are in areas that preclude much entry of water into the soils at present, either under extremely scanty rainfall or under slight rainfall that for one reason or another does not enter the soils. The vegetation in many areas consists of scattered ephemeral grasses and forbs, cacti, and xerophytic shrubs. Some Aridisols furnish limited grazing. If irrigated, many of them are suitable for a wide variety of crops.

Entisols

The unique properties common to Entisols are dominance of mineral soil materials and absence of distinct pedogenic horizons. The absence of features of any major set of soil-forming processes is itself an important distinction. There can be no accessory characteristics. Entisols are soils in the sense that they support plants, but they may be in any climate and under any vegetation. The absence of pedogenic horizons may be the result of an inert parent material, such as quartz sand, in which horizons do not readily form; slowly soluble, hard rock, such as limestone, which leaves little residue; insufficient time for horizons to form, as in recent deposits of ash or alluvium; occurrence on slopes where the rate of erosion exceeds the rate of formation of pedogenic horizons; recent mixing of horizons by animals or by plowing to a depth of 1 or 2 m; or the spoils from deep excavations.

Gelisols

The unique property of Gelisols is the presence of permafrost and soil features and properties associated with freezing and thawing. These features include irregular or broken horizons and incorporation of organic materials in the lower horizons, especially along the top of the permafrost table. Freezing and thawing produce granular, platy, and vesicular structures in surface and subsurface horizons. The increases in soil volume on freezing are considered a major soil-forming process in Gelisols. These soils are confined to the higher latitudes or high elevations, but they make up about 13 percent of the soils in the world, second only to Aridisols.

Histosols

The unique properties of Histosols are a very high content of organic matter in the upper 80 cm (32 in) of the soils and no permafrost. The amount of organic matter is at least 20 to 30 percent in more than half of this thickness, or the horizon that is rich in organic matter rests on rock or rock rubble. Most Histosols are peats or mucks, which consist of more or less decomposed plant remains that accumulated in water, but some formed from forest litter or moss, or both, and are freely drained. The freely drained Histosols are described in chapter 14.

Inceptisols

Inceptisols have a wide range in characteristics and occur in a wide variety of climates. They can form in almost any environment, except for an arid environment, and the comparable differences in vegetation are great. Inceptisols can grade toward any other soil order and occur on a variety of landforms. The unique properties of Inceptisols are a combination of water available to plants for more than half the year or more than 3 consecutive months during a warm season and one or more pedogenic horizons of alteration or concentration with little accumulation of translocated materials other than carbonates or amorphous silica. In addition, Inceptisols do not have one or more of the unique properties of Mollisols, which are a thick, dark surface horizon and a high calcium supply, or the unique property of Andisols, which is the dominance of short-range-order minerals or Al-humus complexes.

Mollisols

The unique properties of Mollisols are a combination of a very dark brown to black surface horizon (mollic epipedon) that makes up more than one-third of the combined thickness of the A and B horizons or that is more than 25 cm thick and that has structure or is not hard or very hard when dry; a dominance of calcium among the extractable cations in the A and B horizons; a dominance of crystalline clay minerals of moderate or high cation-exchange capacity; and less than 30 percent clay in some horizon above 50 cm if the soils have deep, wide cracks (1 cm or more wide) above this depth at some season.

Mollisols characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. Some Mollisols, however, formed under a forest ecosystem, and a few formed in marshes or in marls in humid climates. Mollisols are extensive soils on the steppes of Europe, Asia, North America, and South America.

Oxisols

The unique properties of Oxisols are extreme weathering of most minerals other than quartz to kaolin and free oxides, very low activity of the clay fraction, and a loamy or clayey texture (sandy loam or finer).

Oxisols characteristically occur in tropical or subtropical regions, on land surfaces that have been stable for a long time. Generally, the surfaces are early Pleistocene or much older, but Oxisols can occur on relatively young surfaces when weathered soil material is redeposited. Oxisols developed in a humid climate. Because climates change, however, some are now in an arid environment.

Spodosols

Spodosols have markers in at least an upper sequum of dominant processes that translocate humus and aluminum, or humus, aluminum, and iron, as amorphous materials. The unique property of Spodosols is a B horizon consisting of an accumulation of black or reddish amorphous materials that have a high cation-exchange capacity. This horizon is the spodic horizon. In most undisturbed soils, an albic horizon overlies the B horizon. The spodic horizon has accessory characteristics of coarse texture, high pH-dependent charge, and few bases. Commonly, the cation-exchange capacity is related to the amount of organic carbon rather than to the clay.

Ultisols

Ultisols, like Alfisols, have markers of clay translocation, but they also have markers of intensive leaching that are absent in Alfisols. The unique properties common to Ultisols are an argillic horizon and a low supply of bases, particularly in the lower horizons.

The cation-exchange capacity in Ultisols is mostly moderate or low. The decrease in base saturation with increasing depth reflects cycling of bases by plants or additions in fertilizers. In soils that have not been cultivated, the highest base saturation is normally in the few centimeters directly beneath the surface. Like Alfisols, Ultisols have water, but they have few bases. Without applications of fertilizer, they can be used for shifting cultivation. Because they are commonly warm and moist, however, they can be made highly productive if fertilizer is applied.

Vertisols

These soils have markers of processes related to the failure of soil materials along shear planes (slickensides). Because the soil material moves, the diagnostic properties have many accessory properties. Among them are a high bulk density when the soils are dry, low or very low hydraulic conductivity when the soils are moist, an appreciable rise and fall of the soil surface as the soils become moist and then dry, and rapid drying as a result of open cracks. The unique properties common to Vertisols are a high content of clay, pronounced changes in volume with changes in moisture, cracks that open and close periodically, and evidence of soil movement in the form of slickensides and of wedge-shaped structural aggregates that are tilted at an angle from the horizontal. The development of eluvial/illuvial horizons in some Vertisols suggests that pedoturbation is not rapid enough to preclude long-term translocation processes.

Suborders

Sixty-four suborders currently are recognized. The differentiae for the suborders vary with the order but can be illustrated by examples from two orders. The Entisol order has five suborders that distinguish the major reasons for absence of horizon differentiation. One suborder includes soils that have aquic conditions. These are the soils in areas of marshy recent alluvium and the soils of coastal marshes that are saturated with water and have a blue or green hue close to the surface. This suborder segregates the wet varieties. A second suborder includes soils that are not wet and that consist of recent alluvium, which generally is stratified. This suborder segregates the very young soils that do not have horizons because there is continuing deposition of new sediments. A third suborder includes soils on recently eroded slopes. This suborder segregates soils that are kept young by removal of soil materials at a rate that is more rapid than that of horizon differentiation. A fourth suborder includes sands that may range from recent to old. If old, they either lack the building blocks for pedogenic horizons or do not have enough moisture. Although the reasons for absence of horizons in the sands vary, the sands have many common physical properties, such as a low capacity for moisture retention, high hydraulic conductivity, and susceptibility to soil blowing. The sorting of these differences is continued in the lower categories. The fifth suborder of Entisols includes soils in which horizons have been mixed by deep plowing or other human activities that have destroyed the pedogenic horizons as such but not the fragments of the horizons.

Alfisols has five suborders. As in Entisols, one suborder includes wet soils in which the colors are dominantly gray. A second suborder includes Alfisols that are cold and have a short growing season. A third suborder includes soils that have a udic moisture regime and rarely do not have water available for plants. A fourth suborder has an ustic moisture regime and has extended or frequent periods when the soils do not have water that is available to mesophytic plants in some or all horizons. The fifth suborder includes the Alfisols that have a xeric moisture regime. These soils are cool and moist in winter, but they are dry for extended periods in summer.

The differentiae used in defining the suborders of Alfisols include important properties that influence genesis and that are extremely important to plant growth. The differentiae in six of the other orders closely parallel those of Alfisols. In the remaining orders, differentiae were selected to reflect what seemed to be the most important variables within the orders.

Great Groups

There are more than 300 great groups. At as high a categoric level as possible, it is desirable to consider all the horizons and their nature collectively as well as the temperature and moisture regimes. The moisture and temperature regimes are causes of properties, and they also are properties of the whole soil rather than of specific horizons. At the order and suborder levels, only a few of the most important horizons could be considered because there are few taxa in those categories. At the great group level, the assemblage of horizons and the most significant properties of the whole soil are considered. Although the definition of a great group may involve only a few differentiae, the accessory properties are many times that number.

Differentiae in the great group category segregate soils that have the following properties in common:

Close similarities in kind, arrangement, and degree of expression of horizons.—Exceptions are made for some thin surface horizons that would be mixed by plowing or lost by erosion and for horizons that indicate transitions to other great groups. For example, an argillic horizon that underlies the spodic horizon is permitted in the Spodosol order because that combination is considered to represent a kind of transition between Spodosols on the one hand and Alfisols and Ultisols on the other. Emphasis is placed on the upper sequum in the great group category because it is thought to reflect the current processes and is more critical to plant growth than the deeper horizons.

Similarities in base status.—If the base status varies widely within a suborder, the range is narrowed at the great group level.

The suborders of Alfisols were defined on the basis of moisture regimes. In addition to the argillic horizon that is common to all Alfisols, other kinds of horizons may occur. A fragipan or duripan restricts root development and water movement, which in turn affect current processes of soil formation. These horizons are used as one basis for defining great groups. The argillic horizon may have a fine texture and may be abruptly separated from an overlying albic horizon. This combination also affects root development and water movement, inducing shallow perched ground water and intermittent reducing conditions in the soils. The horizons may be thick as a result of very long periods of development. They may be undergoing destruction, and the soils may have developed a glossic horizon. These features also are used as differentiae for great groups.

In contrast to Alfisols, emphasis in the Entisols was placed on soil moisture and temperature regimes when the great groups were differentiated. Because the various suborders occur in all parts of the world, they have extreme ranges in moisture and temperature regimes, and those regimes affect pedogenesis as well as use and management of the soils.

Subgroups

There are more than 2,400 subgroups. Through the categories of order, suborder, and great group, emphasis has been placed on features or processes that appear to dominate the course or degree of soil development. In addition to these dominant features, many soils have properties that, although apparently subordinate, are still markers of important sets of processes. Some of these appear to be features of processes that are dominant in some other great group, suborder, or order. In a particular soil, however, they only modify the traits of other processes. For example, some soils have aquic conditions and have, throughout their depth, gray colors with reddish or brownish redox concentrations. Other soils have aquic conditions only in their lower horizons, and in those horizons the dominant colors may be shades of brown, red, or yellow with some gray redox depletions. The effects of ground water are apparent in both sets of soils, but they have less importance in the latter set.

Other properties are features of processes that are not used as criteria of any taxon above the subgroup level. For example, a Mollisol at the foot of a slope, where there has been a slow accumulation of materials washed from the higher parts of the slope, may have a greatly overthickened mollic epipedon.

Thus, there are three kinds of subgroups:

Typic subgroups.—These are not necessarily the most extensive subgroups, nor do they necessarily represent the central concept of the great group. In some taxa typic subgroups simply represent the soils that do not have the characteristics defined for the other subgroups.

Intergrades or transitional forms to other orders, suborders, or great groups.—The properties may be the result of processes that cause one kind of soil to develop from or toward another kind of soil or otherwise to have intermediate properties between those of two or three great groups. The properties used to define the intergrades may be:

1. Horizons in addition to those definitive of the great group, including an argillic horizon that underlies a spodic

horizon and a buried horizon, such as a thick layer of organic materials that is buried by a thin mineral soil; *or*

2. Intermittent horizons, such as those described in the section of chapter 1 that deals with the pedon; *or*

3. Properties of one or more other great groups that are expressed in part of the soils but are subordinate to the properties of the great group of which the subgroup is a member. One example of different depths of saturation and reduction was given earlier. Another example might be an Alfisol that has an ochric epipedon a little too thin or a little too light in color to be a mollic epipedon. This feature could result from an invasion of grassland by forest or the reverse, from the coexistence of both grass and forest, or from the erosion caused by human activities.

Extragrades.—These subgroups have some properties that are not representative of the great group but that do not indicate transitions to any other known kind of soil. One example of an overthickened mollic epipedon was given earlier. Other examples are soils that are very shallow over rock (Lithic) or soils that have high amounts of organic carbon (Humic).

Families

In this category, the intent has been to group the soils within a subgroup having similar physical and chemical properties that affect their responses to management and manipulation for use. In some cases soil properties are used in this category without regard to their significance as indicators of soil-forming processes.

The following are defined primarily to provide groupings of mineral soils with restricted ranges in:

1. Particle-size classes in horizons of major biologic activity below plow depth;

2. Mineralogy classes in the same horizons that are considered in naming particle-size classes;

3. Cation-exchange activity classes of certain particle-size and mineralogy classes in the same horizons that are considered in naming particle-size classes;

4. Calcareous and reaction classes in horizons directly below plow depth;

5. Soil temperature classes;

6. Thickness of the soil penetrable by roots; *and*

7. Classes of coatings, cracks, and rupture resistance used in defining some families to produce the needed homogeneity.

These properties carry important interpretive information, including aeration and the movement and retention of water, both of which affect the growth of plants and engineering uses. The differentiae are described in more detail in chapter 21.

Series

The series is the lowest category in this system. More than 19,000 series have been recognized in the United States. The differentiae used for series generally are the same as those used for classes in other categories, but the range permitted for one or more properties is narrower than the range permitted in a family or in some other higher category. For several properties, a series may have virtually the full range that is permitted in a family, but for one or more properties, the range is restricted. The purpose of the series category, like that of the family, is mainly pragmatic, and the taxa in the series category are closely allied to interpretive uses of the system.

Two kinds of distinctions, therefore, are made among series. First, the distinctions among families and among classes of all higher categories also are distinctions among series. A series cannot range across the limits between two families or between two classes of any higher category. Second, distinctions among similar series within a family are restrictions in one or more but not necessarily all of the ranges in properties of the family. Taken collectively, the number of the latter kind of distinctions is too large to be comprehended readily. One can only state the basis for separating individual series. Diagnostic horizons and features provide a framework for differentiating series, but series differentiae need not be limited to the defined diagnostic horizons and features.

The differentiae for series in the same family are expected to meet three tests. The first is that properties serving as differentiae can be observed or can be inferred with reasonable assurance. The second is that the differentiae must create soil series having a unique range of properties that is significantly greater than the normal margin of errors made by qualified pedologists when they measure, observe, or estimate the properties. The third is that the differentiae must reflect a property of the soils. This significance can be reflected in the nature or degree of expression of one or more horizons. The nature of horizons includes mineralogy, structure, rupture-resistance class, texture of the subhorizons, and moisture and temperature regimes. If color is accessory to some other property, it too is included. Degree of horizon expression includes thickness, contrast between horizons or subhorizons, and the nature of boundaries. If horizons are absent, the nature of the whole zone of major biologic activity is considered. The series control section is defined in chapter 21.

Important differences, shown by experience or research to condition or influence the nature of the statements that we can make about the behavior of the soil, should be considered as series differentiae.