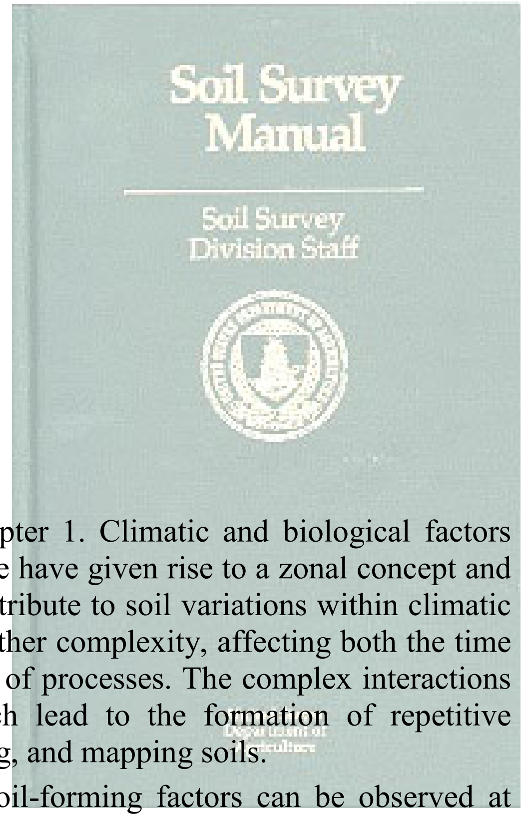
CHAPTER

2 Soil Systematics



The factors of soil formation are discussed in chapter 1. Climatic and biological factors generally produce broad geographic patterns. These have given rise to a zonal concept and definition of soil distribution. Parent materials contribute to soil variations within climatic and vegetative zones. Local topographic patterns add further complexity, affecting both the time of exposure to processes of soil formation and the kinds of processes. The complex interactions among these factors occur in repetitive patterns which lead to the formation of repetitive combinations. These are the basis for defining, identifying, and mapping soils.

The repetitive patterns imprinted in soils by the soil-forming factors can be observed at scales ranging from continental to microscopic. The patterns are the basis for soil identification and mapping at vastly different scales. A system of terminology, definitions, and operations can be ascribed to the various scales. Hierarchical systems of classes and subclasses can be set up to produce groupings at the different scales.

The National Cooperative Soil Survey of the United States has systems of descriptive terminology, class definitions, hierarchical soil groupings, and operations that are applicable to various scales and appropriate to a wide variety of uses. Development of such flexibility has, in turn, required a fairly complex system in which it is important to understand a number of philosophical, conceptual, and operational relationships. Foremost among these are the relationships between mapping units and taxonomic units, site data and mapping unit data, conceptual models and the real entities in the landscape.

Map units are designed to carry important information for the more common uses of soils in the survey area such as small grain, rural living, and small community development. The map units must also be easily recognizable and mappable at scales compatible with the available base maps, the time allocated to collecting the data, and the skills of the surveyors.

In the United States, soil surveys vary in scale and in intensity of observations. The components of map units are designated by taxa in *Soil Taxonomy* (Soil Survey Staff, 1975) and miscellaneous areas if they are present. Soil taxa are modified with phases, such as slope and stoniness to convey more specific information. The phase often is a portion of the range of properties exhibited by the taxon. For example, a certain soil series may have slopes from 3 to more than 60 percent, but map units are shown with narrower ranges—such as 3 to 8, 8 to 15, 15 to 25—in order to provide information that is useful in managing the soils in the area.

Kinds of soils are known best by the characteristics embodied in small samples. Field descriptions of soil include horizon designation; depth and thickness; color; moist and dry; features of ped surfaces and interiors; texture; structure; consistence at several water states; and special features such as roots, pores, nodules, salts, rock fragments, pH, and boundary conditions. Site characteristics of the soil and its immediate surrounding are usually described.

Chemical and physical data are obtained from horizon samples analyzed in a laboratory. Special features of microbial entities and activities are not routinely determined but may be carried out for research or special purposes.

All samples and all models of soils have a purpose in the soil survey program. Small samples from peds and profiles help us describe the properties of points and how they are organized. This mainly gives us a perspective of the results of soil genesis. We only know what is present by the techniques of measurement that are used, although we may speculate about what has been removed, changed, added, or translocated. Profile features are combined into models of soil formation and the processes and events of geomorphology that have influenced and helped shape the hypothesized features. These mental processes of model building permit us to shift readily from considering an ion in solution to the arrangement of horizons in profiles and their stratigraphic relationships across landscapes.

Purposive sampling of soil map units depends on whether the answers or relationships we desire are related in a meaningful way with the features of the soil map units. The actual clues are not necessarily soil properties at all but are features of identification that we associate with the unseen soil models. Mapping in most surveys involves delineating segments of the landscape, cutting out geographic areas, and putting the boundaries on base maps. Tonal shades and patterns on aerial photographs are used to indicate possible changes of vegetation, drainage conditions, materials, and so forth. The patterns of the gray tones are used to delineate areas on maps. As we look at the existing vegetation, we see differences of tones and composition of the species makeup, and we verify or modify the boundary locations of the units accordingly. Configurations of the visible surface of the land, stones, and other features are used as evidence of changes important enough to be recognized as separate areas. Finally, the soils are examined at a few locations to verify the models being used in the mapping process.

Soil surveys are conducted so that all the clues, features, and pieces of evidence that support the delineations that are called soil map units are in fact surrogates for the models that have been established. The measure of models of landscape evolution and soil formation relative to observable landscape areas is provided by the constant testing that goes on in the soil survey. The outdoors is a laboratory in which variability is subject to some level of systematic portrayal. Thus the small items that are used to assist in locating, verifying, modifying, and developing soil models are similar to the criteria used to identify the basis of differentiation in the classification of soils.

Predictions of properties that exist in soil map units and the predictions made about the qualities and suitabilities and responses of areas of land are all based on the relationships that exist between the desired or expected result and the actuality that is represented by the models used in mapping.

Many schemes have been proposed and tested for determining the composition of map units. The same can be said for the distribution of properties that exist, or are thought to exist, in areas of the landscape that can be delineated consistently on base maps. It is fairly well accepted that certain features of soils and of landscapes are not in accord with existing models of distributions in systematic and predictable ways. The frequency of random events can readily be predicted and tested; however, the location of the occurrences associated with events is, and likely will remain, a probabilistic phenomenon. Such aberrant features are what gives rise to most of the inclusions in map units because their occurrence cannot be predicted and mapped with models even at larger scales. It is the nonsystematic features that make all models approximations of what actually takes place. The composition of map units can never be known. It can only be approximated from samples of them.

It is common to employ transects to estimate the composition of map units. The first aspect of composition is to identify the taxonomic components because they are the things that we have learned to identify and recognize. These can be translated or interpreted as responses or properties or whatever has an acceptable relationship. If results are not satisfactory or favorable, it is because the models are being used beyond their capability. As long as one is aware of the probability of accuracy or known variability, then soil survey information can have relevant use.

Transecting carries with it some important assumptions when it is used as a means of purposive sampling for map unit composition. A major assumption is that the points observed along a line will be representative of areas on the land that are shown as map units. This line varies in utility with different landscapes and models developed for soil surveys.

Transects crossing landscape units must cross all parts of the landscape, rather than line up with known patterns of variability as this would unduly bias the results. For example, transects that follow small steam valleys overweigh the alluvial-colluvial material relative to what occurs on the hillslopes and uplands. The differences between accuracy of line and point transects for grid points or sample plots is not the same for all landscapes and is better determined by some preliminary checking. Point transects have proven to be satisfactory for most surveys in the United States. Observations made at points along a transect are usually identified as belonging to a class... often a particular taxon, but they could be a combination of properties such as depth, a thickness, a color, or a structure. Because the assumption that point-to-area relationships are satisfactory, the number of observations in the various classes are handled as samples, and statistical inferences are made about the mean values and the ranges that are thought to exist.

Pedon and Polypedon

In soil surveys the individual parts that make up the soil continuum are classified. The classes are defined to include bodies of soil of significant kinds and sizes. The classes are concepts, not real soils, but they are related to their representatives in nature—the pedon and the polypedon.

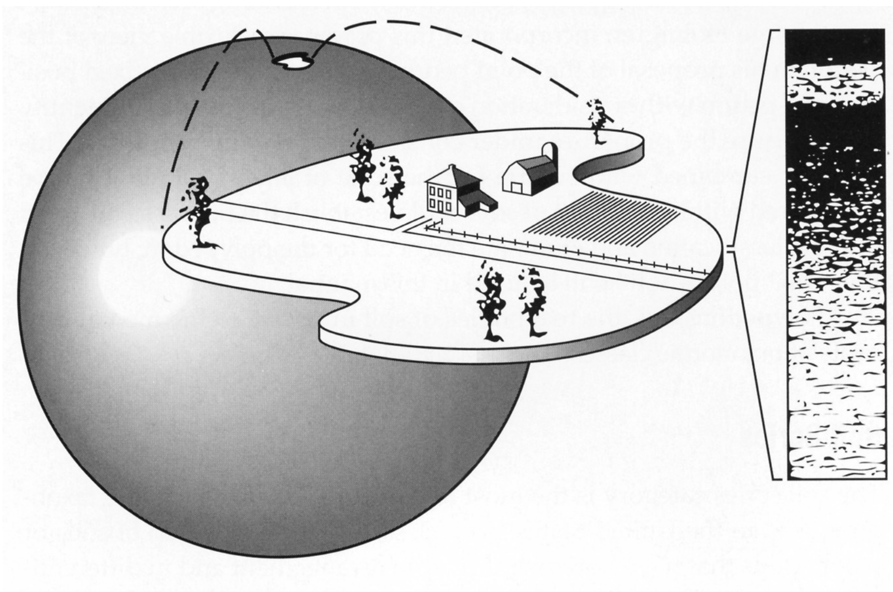
Pedon.—The pedon is presented in Soil Taxonomy (Soil Survey Staff, 1975) as a unit of sampling within a soil. The limits on the area of a pedon establish rules for deciding whether to consider one or two or more kinds of soil within a small-scale pattern of local lateral variability. A pedon is regarded as the smallest body of one kind of soil large enough to represent the nature and arrangement of horizons and variability in the other properties that are preserved in samples.

A pedon extends down to the lower limit of a soil. It extends through all genetic horizons and, if the genetic horizons are thin, into the upper part of the underlying material. The pedon includes the rooting zone of most native perennial plants. For purposes of most soil surveys, a practical lower limit of the pedon is bedrock or a depth of about 2 m, whichever is shallower. A depth of 2 m provides a good sample of major soil horizons, even in thick soil. It includes much of the volume of soil penetrated by plant roots, and it permits reliable observations of soil properties.

The surface of a pedon is roughly polygonal and ranges from 1 m2 to 10 m2 in area, depending on the nature of the variability in the soil. Where the cycle of variations is less than 2 m and all horizons are continuous and nearly uniform in thickness, the pedon has an area of approximately 1 m2. Where horizons or other properties are intermittent or cyclic over an interval of 2 to 7 m, the pedon includes one-half of the cycle (1 to 3 1/2 m). If horizons are cyclic over an interval greater than 7 m, each cycle is considered to contain more than one soil. The range in size, 1 to 10 m2, permits consistent classification by different observers where important horizons are cyclic or repeatedly interrupted over short distances.

Polypedon.—The pedon is considered too small to exhibit more extensive features, such as slope and surface stoniness. The polypedon is presented in Soil Taxonomy as a unit of classification, a soil body, homogeneous at the series level, and big enough to exhibit all the soil characteristics considered in the description and classification of soils (fig. 2-1).

FIGURE 2-1



A schematic diagram of a polypedon as a unit soil body on the Earth's surface, illustrating (a) its characteristic landscape and (b) its unique set of internal properties. Its margins represent the geographic limits of a set of soil properties defined for a soil series. (courtesy of Walter M. Simonson)

In practice, the concept of polypedon has been largely ignored and many soil scientists consider a pedon or some undefined body of more or less similar soil represented by a pedon large enough to classify. Polypedons seldom, if ever, serve as the real thing we want to classify because of the extreme difficulty of finding the boundary of a polypedon on the ground and because of the self-contradictory and circular nature of the concept. Soil scientists have classified pedons, regardless of their limited size, by deliberately or unconsciously transferring to the pedon any required extensive properties from the surrounding area of soil.

George Holmgren incorporated this pragmatic, flexible view of the pedon in his proposal of the point pedon which combines the fixed position of a pedon with consideration of whatever area is needed to identify and measure the properties under consideration (Holmgren, 1988). This concept, combined with criteria for the scale of lateral variability to be considered within one kind of soil, could establish the pedon as the basic unit of classification and eliminate the need for the polypedon; however, the term "polypedon" will be used in this manual.

Polypedons link the real bodies of soil in nature to the mental concepts of taxonomic classes.

Soil Series

The soil series category is the most homogeneous category in the taxonomy used in the United States. As a class, a series is a group of soils or polypedons that have horizons similar in arrangement and in differentiating characteristics. The soils of a series have a relatively narrow range in sets of properties.

Soil series are differentiated on all the differentia of the higher categories plus those additional and significant characteristics in the series control section. Some of the characteristics commonly used to differentiate series are the kind, thickness, and arrangement of horizons and their structure, color, texture, reaction, consistence, content of carbonates and other salts, content of humus, content of rock fragments, and mineralogical composition. A significant difference in any one of these can be the basis for recognizing a different series. Very rarely, however, do two soil series differ in just one of these characteristics. Most characteristics are related, and generally several change together.

New series, variants, and taxadjuncts

Some soils are outside the limits of any recognized soil series and have unique sets of properties. These are potential new series. When such a soil is first recognized, it is described and identified as a taxon of the lowest category in which it can be classified. A phase of that taxon can be used to identify a map unit. In some surveys, including virtually all detailed surveys, greater refinement of definition is needed. For these, the soil is proposed as a new series, but the new series remains tentative until its properties can be described in detail, its extent determined, and any conflicts with established series resolved. If the soil proves to be unique and significant in extent, it is established as a new series.

Before October 1988, a soil that had characteristics outside the limits of any defined series and was less than 800 hectares (2,000 acres) in extent was designated as a *variant*. Variants differed enough in one or more properties from the series for which they were named that major interpretations for comparable phases were different. They were named by adding the word "Variant" to the name of a closely related series, preferably one within the survey area. Variants were potential soil series, and the soil was established as a new series if a significant area of a variant was eventually recognized.

Taxadjuncts are polypedons that have properties outside the range of any recognized series and are outside higher category class limits by one or more differentiating characteristics of the series. The differences in properties are small so that major interpretations are not affected. A taxadjunct is given the name of an established series that is most similar in characteristics. It is an adjunct to, but not part of, the named series. It is treated as if it were a member of the named series, and its interpretations are similar to those for comparable phases of the series for which it is named. The difference from the established series is described. Example: A potential series is in a fine-silty family particle size class, marginal to fine-loamy; however, it differs from an established fine-loamy series in only particle size and no appropriate fine-silty series has been identified. The potential series is given the name of the established series, and a new series is not proposed.

Phases

If a property of a taxon has too wide a range for the interpretations needed or if some feature outside the soil itself is significant for use and management, these are bases for defining phases. Phases commonly include only part of the range of features exhibited by a taxon, but phases can be based on attributes such as frost hazard, character of the deeper substratum, or physiographic position that are not characteristics used to identify taxa but, nevertheless, affect use and management. If these vary from place to place within the survey area, phases can be defined to accommodate the differences.

A soil map unit that bears the name of a phase of a taxon consists dominantly of that phase of the taxon, but it also includes other soil components. The other components are included because of the limitations imposed by the scale of mapping and the number of points that can be examined. *When the limits of soil taxa are superimposed on the pattern of soil in nature, areas of taxonomic classes rarely, if ever, coincide precisely with mappable areas.* Some polypedons are too small to be drawn on the map and are included in delineations and named for another soil. The boundaries between polypedons are not always so obvious that they can be plotted precisely on a map, so part of one polypedon is commonly included in the delineation of an adjacent polypedon. Some polypedons are so intimately intermingled that mappable areas are necessarily identified in terms of two or more taxa. Other polypedons are not easily distinguished from similar adjacent ones and are inadvertently or deliberately included in delineations named for other soils because apparent differences in use and management are small.

Classes of soil properties are not necessarily used directly as phases. Defined class limits of properties are designed for a convenient description of soil, and they can also be used to define phases of soil where appropriate. But they are not useful for all soils. Distinctions significant for one kind of soil are not significant for every other kind. Any single property is significant only through its interactions with other properties. The usefulness of each phase must be repeatedly tested and verified during a survey. Separate phases of a taxon must differ significantly in behavior. If no useful purpose is served by separating them in mapping, similar phases of different taxa may be combined, and the combination described. The interpretations prepared during the course of a survey provide evidence of similarities and differences among map units.

The justification for most phases rests on the behavior of the soils under use. At least one statement about soil behavior must be unique to each phase of a taxon, and the differences of soil properties must exceed normal errors of observation.

Miscellaneous Areas

Some land areas have little or no soil and thus support little or no vegetation without major reclamation. Rock outcrop is an example. Such areas are called miscellaneous areas. The names of the different kinds of miscellaneous areas (discussed later) are used in the same manner as the names of soil taxa to identify map units.

Map Units

A map unit is a collection of areas defined and named the same in terms of their soil components or miscellaneous areas or both. Each map unit differs in some respect from all others in a survey area and is uniquely identified on a soil map. Each individual area on the map is a *delineation*.

Map units consist of one or more components. An individual component of a map unit represents the collection of polypedons or parts of polypedons that are members of the taxon or a kind of miscellaneous area. Parts of polypedons are common when phases are used to divide a taxon. Classes of miscellaneous areas are treated the same as soil taxa in soil surveys. A taxonomic unit description describes the ranges in soil properties exhibited in the polypedon for the maps in a survey area that are referenced by that taxonomic unit. The limits of these ranges are set for the taxonomic class of which a taxonomic unit is a member, but generally the full range allowed by the taxonomic class is not exhibited in a small survey area (<200,000 ha).

A delineation of a map unit generally contains the dominant components in the map unit name, but it may not always contain a representative of each kind of inclusion. A dominant component is represented in a delineation by a part of a polypedon, a complete polypedon, or several polypedons. A part of a polypedon is represented when the phase criteria, such as a slope, requires that a polypedon be divided. A complete polypedon is present when there are no phase criteria that require the subdivision of the polypedon or the features exhibited by the individual polypedon do not cross the limits of the phase. Several polypedons of a component may be represented if the map unit consists of two or more dominant components and the pattern is such that at least one component is not continuous but occurs as an isolated body or polypedon. Similarly, each inclusion in a delineation is represented by a part of a polypedon, a complete polypedon, or several polypedons. Their extent, however, is small relative to the extent of the dominant component(s). Soil boundaries can seldom be shown with complete accuracy on soil maps, hence parts and pieces of adjacent polypedons are inadvertently included or excluded from delineations.

A few delineations of some map units may not contain any of the dominant components named in the map unit description, but contain very similar soils. In most survey areas there are a few soils that occur as mappable bodies, but they have very limited total extent. They are normally included with other map units, if, for all practical purposes, interpretations are the same.

The kinds of map units used in a survey depend primarily on the purposes of the survey and the pattern of the soils and miscellaneous areas in the landscape. The pattern in nature is fixed and it is not exactly the same in each delineation of a given map unit. In soil surveys these patterns must be recognized and map units designed to meet the major objectives of the survey. It must be remembered that soil interpretations are made for areas of land and the most useful map units are those that group similarities.

Designing Map Units

While studying the soil patterns in different landscapes, the soil scientist must keep in mind how best to relate the patterns observed to appropriate map units. The kinds of map units, the level of soil taxa, and the phases needed to satisfy the survey objectives must be determined. This requires many judgements. Every map unit that is tentatively identified is evaluated by two tests: (1) Can it be mapped consistently? (2) Is it needed to meet the objectives of the survey?

Designing map units to indicate significant differences in behavior among soils is particularly important to meet the current objectives of a survey. Reflecting differences in genesis and morphology is also important, even if no immediate differences in interpretations are known. Differences in soil properties that do not affect current interpretations may be important in the future; however, having too many delineations seriously reduces the immediate usefulness of a soil map. A potential benefit must be weighed carefully against the costs incurred in making additional separations. One objective of every soil survey is to record knowledge about soils, but this does not mean that the soil map must show the location of every kind of soil in a survey area or that the publication must record all that has been learned about the soils.

Taxonomic classes provide the basic sets of soil properties with which soil map units are defined. They summarize an immense amount of research and experience related to the significance of soil properties and combinations of properties. They provide predefined sets of soil properties that have been tested for genetic relationships and for interpretative value. Taxa provide a firm base for recognizing the components of potential map units in an unfamiliar area. Using established taxa is much easier than independently sorting out sets of properties and determining significant class limits.

The objectives of a survey determine the kind of map units and the taxonomic level used to identify components of map units. For the more detailed surveys, decisions must be made about what criteria to use to recognize phases of soil series, how broadly or narrowly to define the phases, and whether similar phases of different series have such similar interpretations that they can be combined. For the less detailed surveys, decisions must be made about how the complexities of soil in large areas can be best identified for purposes of the survey, what combinations of soils characterize useful and mappable units, what taxonomic level should be used in naming map units, and which phases contribute to the usefulness of the map units.

The names of soil taxa, along with one or more modifying terms are used to identify the soils in map units. For example, the name "Tama silt loam, 2 to 5 percent slopes," indicates that soils of the Tama series (a Udoll) are dominant in that map unit. The names of taxa of higher categories are also used in map unit names, especially on small scale maps. "Udolls, rolling," for example, identifies a map unit consisting dominantly of soils of the Udoll suborder, which includes Tama and other series. The name of a taxon of the lowest category that accurately identifies the dominant soil is commonly used.

Within each survey, soil maps can be designed with component taxa of low or high categories that reflect narrowly or broadly defined ranges of soil properties. In addition, soil map units can be designed with different compositions of soil taxonomic units and mapping inclusions. This flexibility permits the design of map units that will be most useful for the purposes of a specific survey as well as for the attainment of as much uniformity in mapping as possible.

As methods of measuring soil properties are refined, as experience in the field increases, and as use and management requirements are intensified, progressively narrower ranges in soil properties can be recognized or established. Narrow ranges of properties are not established just because methods permit it. Unnecessary separations are time consuming to delineate consistently, and they make the survey difficult to use. Not separating two significantly different, mappable units, however, makes a survey less useful. The significance of each map unit in meeting the objectives of the survey must be constantly evaluated during the mapping process.

Improper use of phases to designate map units and misinterpretations of soil survey procedures can result in unreasonably detailed soil maps delineating unnecessary map units or ones in less detail than is needed to accomplish the objectives of the survey. Using pre-established classes of selected soil properties—surface texture, depth, slope, accelerated erosion, and stoniness—as phase criteria and then using all combinations of these in defining phases, creates problems. Meaningless map units cause an unnecessary expense.

Phase distinctions must be compatible with natural variability. To illustrate, a series may range in depth to bedrock from 1.5 m to more than 2 m. For some uses, a separation at 1.5 m would be significant. If within a survey area the soils of a series range in depth to bedrock from slightly less than 1.75 m to slightly more, designating two depth phases cannot be justified. The mapping is likely to be inconsistent and the difference of a few centimeters in depth is likely to be of minor significance. In this case it is far better to designate only one phase on the basis of depth to bedrock. The description of the map unit should, of course, give the depth range.

Another example: In some areas a slope of 8 percent is about the upper limit for cropping many soils without special practices for erosion control; yet, in some series a large part of the soil has slopes of less than 3 percent, most of the rest has slopes of 6 to 10 percent, and a small acreage has slopes of 3 to 6 percent. Dividing phases of such soils at 8 percent slope would produce a large number of delineations having a gradient a little below 8 percent and a large number having a gradient a little above 8 percent. The differences in interpretations of the phases thus defined would probably not be consistently significant. For these soils, slope phases could be set at 0 to 3 percent, 3 to 6 percent, and 6 to 10 percent; or, if there is little or no significance of the break at 3 percent, they could be set at 0 to 6 percent and 6 to 10 percent.

Phases must also be compatible with practical needs. In a hypothetical survey area that is relevant to farming, the polypedons of Alpha soils are similar in all properties except stoniness and slope. The areas range from nearly stone-free to very stony and from undulating to steep. The most important single distinction for farming is the distinction between areas that can be cultivated feasibly and areas that cannot. As many as three mappable classes of stoniness could be combined with four mappable classes of slope—a total of 12 potential phases. Four of these twelve phases might be used to distinguish combinations of degrees of slope and degrees of stoniness within the limits that permit cultivation. Using the remaining eight to subdivide the nonarable areas would confuse the user with unnecessary detail more than it would help. Perhaps two, and probably no more than three, phases are adequate for all significant distinctions among nonarable areas if the survey area is to be used primarily for farming. A list of potentially useful phases is as follows:

A. Arable areas:

1. An undulating, nonstony phase
2. An undulating, moderately stony phase
3. A rolling, nonstony phase
4. A rolling, moderately stony phase

B. Nonarable areas:

1. An undulating and rolling, very stony phase
2. A hilly phase (ranging from nonstony to very stony)
3. A steep phase (ranging from nonstony to very stony)

If the soil map is to be used for planning operations related to forestry or other nonfarming activities, other distinctions may be needed.

The object of surveying soils is to gather relevant facts, record the facts on maps, and then interpret the facts. Field records and observations together with other relevant information must be coordinated in defining phases and map units that meet the objectives of a soil survey.

Kinds of Map Units

Soils differ in size and shape of their areas, in degree of contrast with adjacent soils, and in geographic relationships. Four kinds of map units are used in soil surveys to show the relationships: consociations, *complexes, associations,* and *undifferentiated groups*.

Consociations—In a consociation, delineated areas are dominated by a single soil taxon (or miscellaneous area) and similar soils. As a rule, at least one-half of the pedons in each delineation of a soil consociation are of the same soil components that provide the name for the map unit.[1] Most of the remainder of the delineation consists of soil components so similar to the named soil that major interpretations are not affected significantly. The total amount of dissimilar inclusions of other components in a map unit generally does not exceed about 15 percent if limiting and 25 percent if nonlimiting. A single component of dissimilar limiting inclusion generally does not exceed 10 percent if very contrasting. The amount of dissimilar inclusions in an individual delineation of a map unit can be greater than this if no useful purpose would be served by defining a new map unit. The soil in a consociation may be identified at any taxonomic level.

A consociation named for a kind of miscellaneous area is dominated by the kind of area for which it is named to the extent that inclusions do not significantly affect the use of the map unit. Generally, this means that less than about 15 percent of any delineation is soil or less than about 25 percent is other kinds of miscellaneous areas. Percentages may vary, depending on the kind of miscellaneous area and the kind, size, and pattern of the inclusions.

Complexes and associations—Complexes and associations consist of two or more dissimilar components occurring in a regularly repeating pattern. Only the following arbitrary rule related to mapping scale determines whether the name complex or association should be used. The major components of a complex cannot be mapped separately at a scale of about 1:24,000 (fig. 2-2). The major components of an association can be separated at a scale of about 1:24,000 (fig. 2-3). In either case, the major components are sufficiently different in morphology or behavior that the map unit cannot be called a consociation. In each delineation of either a complex or an association, each major component is normally present, though their proportions may vary appreciably from one delineation to another. The total amount of inclusions in a map unit that are dissimilar to any of the major components does not exceed about 15 percent if limiting and 25 percent if nonlimiting, and a single kind of dissimilar limiting inclusion generally does not exceed 10 percent if very contrasting.

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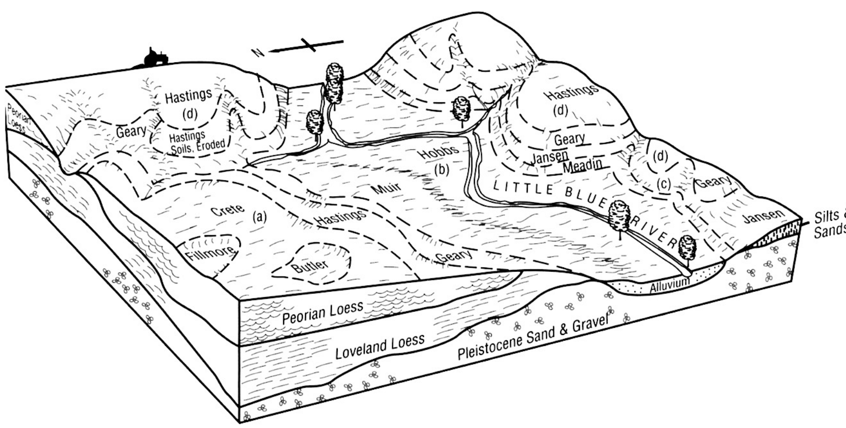
[1] Some consociations may be less than one-half the named soil if most of the remainder of the map consists of two or more soils that are similar to the named soil. The unit is named for the dominant soil.

FIGURE 2-2

An area of a soil complex where plowing 12 inches deep turns up the dark- colored spots in the subsoil. Note the uniform color of the areas on the left that have not been "deep plowed."

FIGURE 2-3



Landscapes of Associations of Soil Series. (Soil Survey Thayer Co., Nebraska).

Undifferentiated groups—Undifferentiated groups consist of two or more taxa components that are not consistently associated geographically and, therefore, do not always occur together in the same map delineation. These taxa are included as the same named map unit because use and management are the same or very similar for common uses. Generally, they are included together because some common feature such as steepness, stoniness, or flooding determines use and management. If two or more very steep soils geographically separated are so similar in their potentials for use and management that defining two or more additional map units would serve no useful purpose, they may be placed in the same unit. Every delineation has at least one of the major components and some may have all of them. The same principles regarding proportion of inclusions apply to undifferentiated groups as to consociations.

Inclusions Within Map Units

In all soil surveys, virtually every delineation of a map unit includes areas of soil components or miscellaneous areas that are not identified in the name of the map unit. Many areas of these components are too small to be delineated separately. The location of some components cannot be identified by practical field methods. Some mapping inclusions are deliberately placed in delineations identified as another map unit to avoid excessive detail of the map or the legend.

Inclusions reduce the homogeneity of map units and may affect interpretations. The objective is to define map units that will contain as few inclusions as practical of components that behave differently from the naming components. Also, map units must be so defined that they can be recognized and delineated consistently in the field.

The number of inclusions reflects the taxonomic purity of map units. The number and degree of contrast of inclusions with the reference taxa can be used to estimate the interpretative purity of map units. The actual amount of inclusions is estimated from observations made during the survey. Adjustments in mapping are made if appropriate.

In the definition of map units, judgement must be exercised about the effects of inclusions on management and about how much effort is justified to keep the amount of inclusions small. In exercising these judgements, visualizing two kinds of differences between components is useful. If differences are small, the components are compared as similar. If differences are large, the components are contrasted as dissimilar.

Similar components are alike or much alike in most properties and share limits of those diagnostic properties in which they differ. Differences are beyond the limits of the reference taxon or phase class, but they generally are within or slightly beyond normal errors of observation. Because only a few limits are shared or the range is small, interpretations for most common uses are alike or reasonably similar and the interpretative value of a map unit is not affected.

Dissimilar components on the other hand, differ appreciably in one or more properties, and the differences generally are great enough to affect major interpretations. Some dissimilar components are limiting, and others are nonlimiting relative to the interpretations being considered.

If an inclusion does not restrict the use of entire areas or impose limitations on the feasibility of management practices, its impact on predictions for the map unit is small. Inclusions of soil components that have less severe restrictions on use than the dominant soil of a map unit do not adversely affect predictions about the unit as a whole. They may even be beneficial. Such inclusions are nonlimiting and the interpretative purity of a map unit for most interpretations is not altered.

For example, the inclusion of many small areas having slopes of 4 to 8 percent in an area having slopes mainly of 15 to 25 percent has no adverse effect on use of the area for most purposes; however, if an inclusion has significantly lower potential for use than the dominant component in the map unit or affects the feasibility of meeting management needs, a small amount in a map can affect predictions greatly. These are the most critical inclusions because they decrease the interpretative purity of map units. Even a small area having slopes of 15 to 25 percent in a map unit dominated by slopes of 4 to 8 percent can seriously affect the use of the area for many purposes. Even small inclusions of Typic Epiaqualfs in areas of Aquic Hapludalfs, for an example, may control and limit the uses of the dominant soil.

Soils that cannot be used feasibly for the same purposes as the surrounding soils are especially critical. They are separately delineated if the map scale permits it and if showing them will improve the usefulness of the map for the major anticipated uses. Areas too small to delineate may be identified and located on the map by special symbols.

Naming Map Units

All map units in a soil survey are named. Different conventions are used for each of the four kinds of map units so that the kind of unit can be determined at a glance. In general, names are as short as is practical; the name of a map unit should be only as long as is necessary to distinguish it from all others in the survey. At times an extra term, not needed to distinguish a phase from all others in the survey, is used so that comparable phases in other areas have the same name.

Although some of the conventions for naming map units are discussed in this chapter, a more complete discussion is provided in the *National Soils Handbook* (Soil Conservation Service). Soil names indicate the categorical level used for identification, but soil taxonomic names are never used alone.

Phases are groupings created to serve specific purposes in individual soil surveys. Phases can be defined for any class or classes of any category. The classes are helpful in describing the soil phases that are important for the survey. Differences in soil or environmental features that are significant to use, management, or behavior are the bases for designating soil phases.

Any property or combination of properties that does not duplicate class limits for a taxon can be used to differentiate phases, and any value of a property can be set to divide phases. The choice of properties and limits are determined by the purpose of the survey and by how consistently the phase criteria can be applied. Because objectives differ from one soil survey to another, limits and ranges of a property or attribute may also differ from one survey to another. In general, phase criteria are given a smaller range where soil use is intensive (as for irrigated farming or urban development) and a larger range where use is extensive (as for forestry or grazing).

The attributes most commonly used in defining phases in soil surveys are:

Texture of the surface layer.—As the surface layer has special significance for use of the soil, texture of the surface layer is commonly indicated in the names of consociations bearing the names of soil series. These phases generally identify the dominant texture of a mineral layer about equal in thickness to that commonly mixed in tillage, which is generally 12 to 25 cm. If the layer has not been mixed, the texture that would be produced by mixing is estimated. If, after mixing, the layer is organic, terms for organic material are used to name the phase. In some areas such as deserts, where the surface layer is normally thin and cultivation is unlikely, the texture of the A horizon can be used in naming phases even if it is less than 12 cm thick.

Some mineral soils have a thin layer at the surface that contrasts sharply with the next layer. Such soils may be designated as separate phases if they are unlikely to be tilled and if clearly significant to use or management. On rangeland, for example, the texture of the uppermost few centimeters of soil is important. A thin layer of sandy material at the surface may mean the difference between success and failure of seedings on some soils. For some surveys, such layers need to be recognized and their areas delineated. Moreover, a thin cover of silt or clay is an important distinction.

Conceivably, other kinds of phases based on texture could be useful in mapping, but they should be used only if the indicated property has a major and lasting effect on interpretations.

Deposits on the surface.—Some soils have received deposits of material thick enough to influence interpretations of the soil but not thick enough to change the classification. Depositional phases of the buried soils may be recognized:

Overblown: A recent deposit of wind-blown material on the surface of an older soil can be identified consistently throughout the area and is thick enough to influence use, management, or behavior.

Wind hummocky: Recent wind-laid deposits form a fine pattern of hummocks that markedly alter management requirements of the soil. The original soil is identifiable throughout most of the area, although it is covered in spots.

Overwash: Material deposited by water that contrasts with the underlying soil and is thick enough to influence management requirements significantly. Ordinarily, overwash phases are not used for very young alluvial soils that have weakly expressed genetic horizons.

Texture terms in the names of map units describe the material currently at the surface. Phases may be recognized for soils covered by a thin layer of volcanic ash. Such phases are generally used only if needed to distinguish the phase from another phase that lacks the ash cover.

Rock fragments.—Rock fragments at the surface and in the surface layer are commonly used as phase distinctions. Kinds of rock fragments are defined by shape and size in chapter 3.

Phases of the smaller rock fragments accommodate most of the detailed phase distinctions that generally can be made accurately by field methods. The term "gravelly" is used in the examples of the names that follow, but the adjectives for each of the other kinds of rock fragments, such as cobbly or channery, are substituted as appropriate. The effect of 20 percent fine gravel on the use of arable soil, for example, is quite different from the effect of 20 percent flagstones; therefore, the phase limits may differ for larger fragments.

The following definitions are applicable to arable soils. For other uses—such as forestry, range, or recreation—the sizes, shapes, amounts, and mixtures of rock fragments have different significance. Pebbles, cobbles, and stones influence forestry much less than they do cultivation, although they could affect access and reforestation.

Nongravelly. The surface layer may contain enough pebbles to affect special uses that tolerate few if any rock fragments, but the pebbles do not interfere with the tillage of such field crops as corn. The volume is less than 15 percent. A slightly gravelly phase can be recognized for soils that are used for special purposes, such as growing turf.

Gravelly. The surface layer contains enough pebbles to interfere with tillage of common field crops. Generally, however, tillage is performed in the same manner and with the same equipment as for soils free of fragments. The pebbles are a nuisance. They may cause some equipment breakage, but they cause few major delays in field operations. The effects of the pebbles on the quality of tillage are small or moderate, depending on the kind of operation. The volume of pebbles is 15 to 35 percent.

Very gravelly. The surface layer contains enough pebbles to interfere seriously with the tillage of common field operations. The quality of tillage operations is affected. The kinds of crops that can be grown is restricted, the precision of planting and of fertilizer placement is reduced, and young plants are frequently covered during tillage. The volume of pebbles is 35 to 60 percent.

Extremely gravelly. The surface layer contains so many pebbles that tillage of the common field crops is often impractical, although not necessarily impossible. Tillage implements must force their way through a mass of pebbles that have fine earth between them. The volume of pebbles is more than 60 percent.

The rock fragments in the surface layer commonly span two or more size classes. The included fragments may be of more than one shape. The name of the kind of fragment that is judged most important in limiting the management of the soil is used in the phase designation. Generally, the largest fragments that are present in significant amounts are the most restrictive on soil use.

Classes of stoniness and boulderiness (chapter 3) are also used to define phases. The following phases of the larger rock fragments represent about the maximum detail that can be mapped consistently in most soil surveys. "Bouldery" is substituted for "stony" as appropriate.

Stony. The areas have enough stones at or near the surface to be a continuing nuisance during operations that mix the surface layer, but they do not make most such operations impractical. Conventional, wheeled vehicles can move with reasonable freedom over the area. Stones may damage both the equipment that mixes the soil and the vehicles that move on the surface. Usually, these areas have class 1 stoniness. If necessary in a highly detailed survey, these areas may be designated as "slightly stony" and "moderately stony."

Very stony. The areas have so many stones at or near the surface that operations which mix the surface layer either require heavy equipment or use of implements that can operate between the larger stones. Tillage with conventionally powered farm equipment is impractical. Wheeled tractors and vehicles with high clearance can operate on carefully chosen routes over and around the stones. Usually, these areas have class 2 stoniness.

Extremely stony. The areas have so many stones at or near the surface that wheeled powered equipment, other than some special types, can operate only along selected routes. Tracked vehicles may be used in most places, although some routes have to be cleared. Usually, these areas have class 3 stoniness.

Rubbly. The areas have so many stones at or near the surface that tracked vehicles cannot be used in most places. Usually, these areas have class 4 or 5 stoniness. If necessary in a highly detailed survey, they may be designated as "rubbly" and "very rubbly." If the soil has stones, boulders, and smaller fragments, the name includes the kind of rock fragment that are most limiting in the use or management of the soil. This is not necessarily the kind that is most abundant or the kind that is used to modify texture class of horizons in the profile description.

Rockiness. Map units, consisting of about 0.1 to 10 percent Rock outcrop, can be named either as "rocky" phases or as complexes or associations of soil and Rock outcrop. Map units consisting of more than 10 percent outcrop are normally named as complexes or associations of soil and Rock outcrop. Where rockiness phases are used, both "rocky" and "very rocky" phases can be named. Commonly, map units with less than 2 percent Rock outcrop are named "rocky" and those with 2 to 10 percent "very rocky."

Slope. The slope range of some soil taxa is narrow; in others, it is wide enough to include differences that are important for soil use and management. Slope phases are used to divide soil series or other taxa as may be needed for the purpose of the survey.

Slope gradient, complexity, shape, length, and aspect are all potential bases for phase distinctions. By far the most commonly used is gradient. Complexity is also used in many surveys. Slope length can often be appraised directly from delineations on the map. In many cases, the significance to use and management of slope length depends on the kind of landscape in which the soil occurs. Shape is seldom used as a phase distinction; differences in shape are commonly related to differences in internal properties that distinguish taxa. Slope aspect is used mainly in high latitudes.

Phases defined on the basis of slope should fit the landscape. They should be so distinct that they can be identified and mapped consistently without adding useless complexity to the map. In addition, such phases should separate areas that have significant differences in suitability or management needs.

A uniform system of slope classes should not be used indiscriminately as the basis for differentiating phases. Slope phases that have narrow ranges in gradient may be needed for soils that can be used intensively. For other soils having additional limitations, such as stoniness, these narrow ranges may be useless. The limits of slope phases should be based on data or experience in order to indicate the most useful distinctions for each kind of soil. Range in the slope of a phase of one series may encompass the ranges of two or more phases of another series. A single set of slope classes that would serve as phase distinctions for all soils is impractical because of the varied relationships of slope to mappable landscapes and to the use and management of different kinds of soils.

Table 3-1 defines slope classes in terms of flexible limits for both simple and complex slopes. The flexible limits permit use of terms to identify most distinctions of slope that may be needed. Names may use either numerical gradient limits, with or without designations of complexity, or descriptive terms. Slope terms for map units for taxa above the series are generally given in descriptive terms. The word "slopes" is used if gradient is specified as a percentage, but it is omitted if descriptive terms are used.

Depth.—Soil depth phases are used where variations in depth to a contrasting layer are significant to soil use, management, or behavior. Terms for depth classes in Chapter 3 are generally used in naming phases, but modifications are needed in some areas. For instance, the class "moderately deep," ranging from 50 to 100 cm, may be too broad to satisfy the objective of a particular survey. This range can be divided, with perhaps one class ranging in depth from 50 to 75 cm and the other from 75 to 100 cm, if the more narrowly defined phases occur in a consistent pattern within the survey area and can be mapped. Generally, the phase that covers the least acreage is given the depth designation. If the deeper phase is more extensive, "moderately shallow" is used to designate the shallower phase. If the shallower phase is more extensive, "moderately deep" is used to designate the deeper phase. In some surveys, using the standard class terms may be misleading. For example, if a series that is normally more than 175 cm deep to bedrock has a phase that is 150 to 175 cm deep, calling the less extensive phase "deep" could be construed to mean that the phase is deeper than normal. In such cases, depth limits can be specified in the phase name, or substratum phase terminology can be used instead.

Substratum.—Where underlying material contrasts sharply with the material above and interpretations are affected, substratum phases are used. The kind of contrasting material is indicated in the name of the map unit. Some examples of commonly used substratum phases are: *gravelly substratum, sandy substratum, silty substratum, shale substratum, and till substratum*. These terms are descriptive and not mutually exclusive. Where there is a choice between using a depth phase or a substratum phase to identify a map unit, a depth phase is generally used if the contrasting layer is bedrock.

Soil water.—Phases are used to distinguish differences in soil-water state, water table level, drainage, and the like where the range of the taxon in one or more of these properties needs to be divided for purposes of the survey. Significant differences in these factors are commonly reflected in differences in soil morphology and are distinguished at the series level. In some soils, however, evidence of wetness, such as redoximorphic features, does not fully reflect the natural drainage or wetness of the soil. These soils may not be differentiated at the series level with the refinement needed for the purposes of the survey.

Examples of soil water phases commonly used are: *high water table, poorly drained, slightly wet,* and *drained*. Some soils have properties that reflect former wetness, but they have been drained artificially; "drained" phases can be used to separate drained areas from undrained. In other soils, a water table fluctuates below the depth where properties are criteria for defining series; "water table" phases can be used to identify such soils.

Salinity.—Saline phases are used to distinguish between degrees of salinity that are important for soil use or management. Electrical conductivity values and observations of plant growth are guides for recognizing phases.

Designation of salinity phases depends on the various uses likely to be made of the soils and the effect of excessive amounts of salt on the uses. In farming areas, the crops most likely to be grown must be considered. Management induced salinity that fluctuates widely with management practices generally would not be a basis for phase distinctions.

Vegetation, especially the native cover, often shows the location of saline soils and their boundaries. Using vegetation, landform, and other features as guides and correlating these field observations with laboratory or field analyses of soil samples, the surveyor can usually draw boundaries with reasonable accuracy. Plants, however, vary in their tolerance of salt by species, variety, age, and perhaps other factors. Some plants are not good indicators of salinity because they grow well in soils that may have excessive amounts.

Other problems must also be considered in designating salinity phases. Different kinds of salts and combinations of salts have varied effects on soil behavior. In many soils, salts are transitory; in others, they are permanent. Excessive sodium may or may not be associated with excess salinity. The following classes of salinity, which are a general guide to naming phases, refer to the presence of salts in the soil. Salinity classes are defined in chapter 3.

Nonsaline: Effects of salinity on plant growth are negligible. Salinity is mainly class 0 and 1. "Nonsaline" is omitted from the names of mapping units unless the soil taxon is typically saline. A very slightly saline phase may be useful in some surveys for crops extremely sensitive to salts.

Slightly saline: Growth of many plants is affected. Yields of such plants as bromes, sunflower, corn, and peas are reduced seriously. Western wheatgrass, kale, and barley are affected little. Salinity is mainly class 2.

Moderately saline: Only plants tolerant of salinity, such as western wheatgrass, beets, and barley, grow well. Yields of these are commonly reduced. Salinity is mainly class 3.

Strongly saline: Only the most tolerant halophytic plants, such as saltgrass, grow well. Salinity is mainly class 4.

Terms for saline phases follow terms for surface texture in phase names.

Sodicity.—For some soils, recognizing a "sodic" phase is useful. The term "sodic" is used as a phase designation, if needed, generally without terms for degrees of sodicity.

Physiography.—Landform or physiographic position may be used as a phase criterion to distinguish phases of a single taxon. A soil in a deposit of loess 3 meters thick on a terrace, for example, may be so much like a soil in a similar deposit on a till plain that the two are members of the same taxon. For some uses, however, the two soils need to be distinguished on the map. A physiographic phase can be used to identify the less extensive soil.

Examples of terms that have been used to designate physiographic phases are: *bench, depressional, fan, karst, ridge, and terrace*. The terms generally identify phases that differ in position from what is typical for the soil. The typical physiography is not given in a phase name. The physiographic phase designation follows the term for surface texture and precedes any terms for slope or erosion.

Erosion.—Differences in soil potential for use, management needs, or performance because of accelerated erosion are a basis for recognizing phases. Phases of eroded soil are identified on the basis of the properties of the soil that remains, although the amount of soil lost is estimated and noted. In some places, erosion has changed the taxonomic classification of a soil.

Properties related to natural erosion are a part of the definition of a taxon, not bases for erosion phases. Erodibility, too, is an inherent quality of a soil and not itself a criterion for erosion phases.

Eroded phases are defined so the boundaries on the soil maps separate soil areas of unlike suitabilities and soil areas of unlike management needs and responses.

Guidelines for naming phases of soil that are eroded by water are as follows. Erosion classes are defined in chapter 3.

Slightly eroded: Erosion has changed the soil enough to require only slight modification of management from that of the uneroded soil; potential use and management remain generally the same. Most slightly eroded soils have class 1 erosion. Slightly eroded areas are not distinguished from uneroded areas in most surveys.

Moderately eroded: Generally, the plow layer consists of a mixture of the original A horizon and the underlying horizons. Most mapped areas of moderately eroded soils have patches in which the plow layer consists wholly of the original A horizon and others in which it consists wholly of underlying horizons. Shallow gullies may be present in some places. Erosion has changed the soil to such an extent that required management or the response to management differs in major respects from that of the uneroded soil. In most moderately eroded soils, ordinary tillage implements reach through the remaining A horizon or well below the depth of the original plowed layer. Most moderately eroded soils have class 2 erosion.

Severely eroded: Severely eroded phases commonly have been eroded to the extent that the plow layer consists essentially of material from underlying horizons. Patches in which the plow layer is a mixture of the original A horizon and underlying horizons may be present within some delineations. Shallow gullies, or a few deep ones, are common in some places. Erosion has changed the soil so much that (1) the eroded soil is suited only to uses significantly less intensive than the uneroded soil, such as use for pasture instead of crops; (2) the eroded soil needs intensive management immediately or over a long period to be suitable for the same uses as the uneroded soil; (3) productivity is reduced significantly; or (4) limitations for some major engineering interpretations are greater than on the uneroded soil. Most severely eroded soils have class 3 erosion.

A "gullied" phase can be recognized if gullied land occupies less than about 10 percent of the map unit. Gullied phases are used for areas having gullies so deep that intensive measures, including reshaping, are required to reclaim the soil. Where the areas are more than 10 percent gullied land, the map units are named as complexes or associations of soil and gullied land.

Guidelines for designating phases of soil eroded by wind are as follows:

Eroded (blown): Wind has removed enough soil that required management differs significantly from that of the uneroded soil, but suitabilities for use remain the same. The term "moderately" is understood.

Severely eroded (severely blown): Wind has removed much of the soil or has shifted it from place to place within the area. Suitability for use is different from that of the uneroded soil, unless extensive reworking is done and/or intensive management practices are used.

Many areas identified as moderately and severely wind eroded are, in fact, mixtures of small areas of uneroded soil and soil eroded to various degrees. The amount of erosion throughout a delineation can be described only in general terms.

Thickness.—The solum and the various horizons in soil have characteristic ranges in thickness for each taxon. Thickness phases may be used to divide the range of thickness of the solum or of the upper horizons. Phases are not used to differentiate thickness of the subsoil or the substratum. Four thickness phases are used:

Thick surface: The thickness of the A horizon or of the A and E horizons combined is within the thicker half of the range for the taxon.

Thin surface: The thickness of the A horizon or of the A and E horizons combined is within the thinner half of the range for the taxon.

Thick solum: The thickness of the solum is within the thicker half of the range for the taxon.

Thin solum: The thickness of the solum is within the thinner half of the range for the taxon.

A term is used for the less extensive of two thickness phases. For example, most delineations of a given soil may have an A horizon that is dominantly between 25 and 35 cm thick. If the A horizon is dominantly 35 to 40 cm thick in other delineations of the same soil and the difference is significant for purposes of the survey, a thick-surface phase can be recognized. The phase in which the A horizon is dominantly 25 to 35 cm thick is the norm; thickness of the A horizon is described for this phase but is not identified in the name.

Climate.—In some places, especially in mountainous or hilly areas, precipitation or air temperature can differ greatly within short distances, yet these differences may not be reflected in internal properties of the soil. Air drainage can differ enough from one location to another to produce a difference in the dates of the last killing frost in the spring or the first in the fall, or one area may be frost free. Climatic phases are used for these situations.

Only two climatic conditions are recognized for a given taxon: (1) the common climate, the climate that influences the greatest extent of the taxon, from which the climate designation is omitted, and (2) a departure from the common climate, for which a climatic designation is used. The departure may be in either of two directions from the norm: *warm or cool, high precipitation or low precipitation*. Each of the terms is connotative only in reference to the common climate of the taxon and must be described specifically for each phase to which it is applied.

In many places, especially on plains, precipitation or temperature changes gradually over distance. A soil in a single survey area commonly includes only part of the range for the series. Climatic phases generally are not used if only part of the range is within a soil survey area. Climatic phases are local distinctions. They are used where temperature or precipitation differs markedly between parts of a survey area.

Other.—A great variety of phase distinctions can be made. In addition to those already described, others may be needed to provide suitable map units; for example: *frequently flooded, occasionally flooded, burned, calcareous, leached surface, dark surface*. "Burned," for example, might be used for organic soils that have lost enough of their organic material by fire to alter their potential use or their management requirements.

The phases designated by special terms are defined to fit special kinds of soils. Such phases are defined according to the common properties of the taxon of which they are members. Thus, the terms usually have different specific meanings when used for different taxa and in different survey areas.

Miscellaneous Areas

Miscellaneous areas have essentially no soil and support little or no vegetation. This can be a result of active erosion, washing by water, unfavorable soil conditions, or man's activities. Some miscellaneous areas can be made productive but only after major reclamation efforts. Map units are designed to accommodate miscellaneous areas, and most map units named for miscellaneous areas have inclusions of soil. If the amount of soil exceeds the standards for inclusions defined in this chapter, the map unit is named as a complex or association of miscellaneous area and soil.

Following are discussions of recognized kinds of miscellaneous areas.

Badland is moderately steep to very steep barren land dissected by many intermittent drainage channels. Ordinarily, the areas are not stony. Badland is most common in semiarid and arid regions where streams cut into soft geologic material. Local relief generally ranges between 10 and 200 meters. Potential runoff is very high, and erosion is active.

Beaches are sandy, gravelly, or cobbly shores washed and rewashed by waves. The areas may be partly covered with water during high tides or storms.

Blown-out land consists of areas from which all or most of the soil material has been removed by extreme wind erosion. The areas are generally shallow depressions that have flat or irregular floors. In some places the floor is a layer of material that is more resistant to wind than the removed material or is a layer of pebbles or cobbles; or, the floor may have been formed by exposure of the water table. Areas covered by water most of the year are mapped as Water. Some areas have a few hummocks or small dunes. Few areas of blown-out land are large enough to be delineated; small areas can be shown by spot symbols.

Cinder land is composed of loose cinders and other scoriaceous magmatic ejecta. Water-holding capacity is very low, and trafficability is poor.

Cirque land consists of areas of rock and rubble in characteristically cirque shape. The shape is caused by glacial erosion.

Dumps are areas of smoothed or uneven accumulations or piles of waste rock and general refuse. Dumps, mine consist of areas of waste rock from mines, quarries, and smelters. Some dumps with closely associated pits are mapped as Dumps-Pits complex.

Dune land consists of sand in ridges and intervening troughs that shift with the wind.

Glaciers are large masses of ice formed, at least in part, on land by the compaction and recrystallization of snow. They may be moving slowly downslope or outward in all directions because of the stress of their own weight; or, they may be retreating or be stagnant. A little earthy material may be on or in the ice.

Gullied land consists of areas where erosion has cut a network of V-shaped or U-shaped channels. The areas resemble miniature badlands. Generally, gullies are so deep that extensive reshaping is necessary for most uses. Small areas can be shown by spot symbols. Phases indicating the kind of material remaining may be useful in some places.

Gypsum land consists of exposures of nearly pure soft gypsum. The surface is generally very unstable and erodes easily. Trafficability is very poor. Areas of hard gypsum are mapped as Rock outcrop.

Lava flows are areas covered with lava. In most humid regions, the flows are of Holocene age, but in arid and very cold regions they may be older. Most flows have sharp, jagged surfaces, crevices, and angular blocks characteristic of lava. Others are relatively smooth and have a ropy glazed surface. A little earthy material may be in a few rocks and sheltered pockets, but the flows are virtually devoid of plants other than lichens.[2]

Oil-waste land consists of areas where liquid oily wastes, principally saltwater and oil, have accumulated. It includes slush pits and adjacent areas affected by the liquid wastes. The land is barren, although some of it can be reclaimed at high cost.

Pits are open excavations from which soil and commonly underlying material have been removed, exposing either rock or other material. Kinds include Pits, mine; Pits, gravel; and Pits, quarry. Commonly, pits are closely associated with Dumps.

Playas are barren flats in closed basins in arid regions. Many areas are subject to wind erosion and many are saline, sodic, or both. The water table may be near the surface at times.

Quarries (see Pits).

Riverwash is unstabilized sandy, silty, clayey, or gravelly sediment that is flooded, washed, and reworked frequently by rivers.

Rock outcrop consists of exposures of bare bedrock other than lava flows and rock-lined pits. If needed, map units can be named according to the kind of rock: Rock outcrop, chalk; Rock outcrop, limestone; Rock outcrop, gypsum. Many rock outcrops are too small to be delineated as

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[2] Lava flows in very wet climates that support a nearly continuous plant cover, even though the amount of fine earth is small, are classified as soil and not as lava flows. Some soils of this kind have been in place for less than 100 years.

areas on soil maps but can be shown by spot symbols. Some areas are large, broken by only small areas of soil. Most rock outcrops are hard rock, but some are soft.

Rubble land consists of areas of cobbles, stones, and boulders. Rubble land is commonly at the base of mountains but some areas are deposits of cobbles, stones, and boulders left on mountainsides by glaciation or by periglacial processes.

Salt flats are undrained flats that have surface deposits of crystalline salt overlying stratified very strongly saline sediment. These areas are closed basins in arid regions. The water table may be near the surface at times.

Scoria land consists of areas of slag like clinkers, burned shale, and fine-grained sandstone remaining after coal beds burn out.(Scoria land should not be confused with volcanic slag.)

Slickens are accumulations of fine-textured material, such as that separated in placer-mine and ore-mill operations. Slickens from ore mills consist largely of freshly ground rock that commonly has undergone chemical treatment during the milling process. Slickens are usually confined in specially constructed basins.

Slick spots are areas having a puddled or crusted, very smooth, nearly impervious surface. The underlying material is dense and massive. The material ranges from extremely acid to very strongly alkaline and from sand to clay.

Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas.

Water includes streams, lakes, ponds, and estuaries that in most years are covered with water at least during the period warm enough for plants to grow; many areas are covered throughout the year. Pits, blowouts, and playas that contain water most of the time are mapped as Water.

Records and Definitions of Soil Taxa

Keeping definitions and names of soil taxa up to date is essential for identification of map units, for correlation of soils nationwide, and for transfer of information about soils at one place to similar kinds of soil elsewhere.

Definitions and names of soil taxa can be kept by different methods. The methods used are modified from time to time. Some kind of centralized system is needed to obtain a nationwide perspective, to maintain standards for defining soil taxa, to assemble field and laboratory data, and to disseminate information to the field.

Soil Series Definitions

Soil series are used for naming most map units of soil surveys in the United States. Over time, the concepts of the series category and of individual series have changed, but more than 16,000 series are now defined and named. These definitions are the framework within which most of the detailed information about soils of the United States is identified with soils at specific places. These definitions also provide the principal medium through which detailed information about the soil and its behavior at one place is projected to similar soils at other places.

Rigorous standards for definitions of soil series ensure that names and descriptions for the same kinds of soils are consistent from survey to survey. Consistency is a major objective of the correlation process. The classes of the soil series category are not static. As new knowledge is acquired, definitions of some established series must be modified. New series are defined for newly recognized kinds of soils. Changes in criteria or limits of taxa in higher categories often require modification of definitions of member series.

Keeping records of series names and updating definitions of series is a continuing process. The changes should be accomplished in ways that detract the least from the predictive value associated with the earlier definitions and names. A centralized system for keeping records of soil series names and definitions ensures that names and definitions of soil series meet the rigorous standards needed in a national soil survey program.

Official soil series descriptions.—Each soil series must be defined as fully and accurately as existing knowledge permits. This applies to proposed soil series used in an individual survey as well as to established series. To ensure the inclusion of essential information and to permit comparison of series definitions, a standard format for recording specific kinds of information is used.

Official soil series descriptions record definitions of soil series and other relevant information about each series. The format, the kind, and the amount of detail may change from time to time, but detailed definition and a series interpretation record are essential. General, descriptive information is also needed to aid the reader in identifying the soil in the landscape and relating it to other kinds of soil.

An official soil series description should include at least the following:

1. Full taxonomic name of the family taxon for which it is a member. This indicates the classes that provide limits of properties that are diagnostic for the series at all categorical levels, except for those between series of the same family.
2. A description of a typical pedon and its horizons, describing each in as much detail as necessary to recognize its taxonomic class. Horizons that are diagnostic for the pedon must be described.
3. A statement of the ranges of properties of the series. This section also contains statements about the relationship of the series control section and diagnostic horizons to vertical subdivisions of the typical pedon.
4. A statement distinguishing the series from "competing series" with which it might be confused. Competing series are mainly those that share common limits with the series described or are members of the same family.
5. A statement that identifies at least one specific place that represents a norm for the series—a "type location." A type location should be described accurately enough so that it can be located in the field.

Descriptive parts of an official soil series description are not required to define the series, but they aid the reader. All parts are not equally important for all soils. Many descriptions include the following:

1. Landform and physiographic position of the series, including its position relative to other landscape elements with which it is associated.
2. Evolution of the landscape. Influences of the soil-forming factors on the genesis of the series should be identified.
3. Parent-material: The kind of mineral or organic material in which the soil formed, including kinds of rock from which the regolith was derived if that can be determined.

4. Drainage of the soil by drainage class or other means of description relative to soil moisture regimes. Seasonal wetness or dryness may be important.
5. Other kinds of soil with which the series is closely associated geographically.
6. Major uses of the soil and dominant kinds of vegetation that grow on it. Native plants are identified, if known.
7. Rationale for classification. Implicit assumptions related to family classification may be described when laboratory data are not available.
8. Distribution and extent: the known geographic distribution and whether the soil occupies a large, small, or intermediate aggregate area.
9. Year and the survey area where the series was proposed or established.
10. Name of the person who prepared and approved the series description and the date it was prepared or approved.
11. References to available laboratory data.
12. Interpretations for common uses of the soil. [3]

Other Taxa

Soil series identified in individual surveys are classified in specific taxa of higher categories. The limits of most properties of soil series are set by the limits of the higher taxa in which they are classified. Soil Taxonomy (Soil Survey Staff, 1975) is the basic reference book for identification, classification, nomenclature, and correlation of kinds of soils for categories above the series.

During a survey, the taxonomic system is tested and retested many times. The results of these tests are reported at field reviews and at the field correlation. Problems in mapping or identifying soils and inconsistencies between the system and observed properties of the soils are recorded in field review reports and correlation memoranda. After appraising these reports, supervisory soil scientists call any inadequacies to the attention of the office responsible for keeping the system up to date.

Orders of Soil Surveys

All soil surveys are made by examining, describing, and classifying soils in the field and delineating their areas on maps. Some surveys are made to serve users who need precise information about the soil resources of areas a few hectares or less in size. These surveys require refined distinctions among small, homogeneous areas of soil. Others are made for users who need a broad perspective of heterogeneous, but distinctive, areas of thousands of hectares. A soil survey made for one group of users may not serve the other group well.

The elements of a soil survey can be adjusted to provide the most useful product for the intended purposes. Different intensities of field study, different degrees of detail in mapping,

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[3] Methods and conventions for developing and displaying soils series interpretations will be described in chapter 6.

different phases or levels of abstraction in defining and naming map units, and different map unit designs produce a wide range of soil surveys. Adjustments in these elements form the basis for differentiating five orders of soil surveys (table 2-1).

Recognition of these different levels of detail is helpful for communicating about soil surveys and maps, even though the levels cannot be sharply separated from each other. The orders are intended to aid in the identification of the operational procedures used to conduct a soil survey. They also indicate general levels of the quality control that is applied during the survey. These levels affect the kind and precision of subsequent interpretations and predictions. The orders differ in the following elements:[4]

I. The soil survey legend, including

- the kinds of map units: consociations, complexes, associations, and undifferentiated groups, and
- the kinds of soil taxa for identifying the map units: soil series, families, subgroups, great groups, suborders, orders, and phases of them;

II. The standard for purity of delineated soil areas, including

- the minimum area of a limiting dissimilar soil that must be delineated separately and thus excluded from areas identified as another kind of soil, and
- the maximum percentage of limiting dissimilar inclusions that is permissible in a map unit;

III. The field operations necessary to identify and delineate areas of the map units within prescribed standards of purity; and

IV. The minimum map scale required to accommodate the map units of the legend, the standards of purity, and the map detail justified by field methods.

[4] "Delineations", "map units", "complex", "consociation", "association", "group", "similar soils", "dissimilar soils", "limiting dissimilar soils", and "inclusion" are explained in chapter 2. Soil survey legends, maps, and map scales are discussed in chapter 4. Chapter 5 explains information-recording procedures. The levels of soil classifications are explained in chapter 5 of *Soil Taxonomy*.

Table 2-1. Key for Identifying Kinds of Soil Surveys

Level of data needed	Field procedures	Minimum-size delineation (hectares)[1]	Typical components of map units[2]	Kind of map units	Appropriate scales for field mapping and publications
1st order - Very intensive (i.e., experimental plots or individual building sites.)	The soils in each delineation are identified by transecting or traversing. Soil boundaries are observed throughout their length. Remotely sensed data are used as an aid in boundary delineation.	1 or less	Phases of soil series, miscellaneous areas.	Mostly consociations, some complexes, miscellaneous areas.	1:15,840 or larger
2nd order - Intensive (e.g. general agriculture, urban planning.)	The soils in each delineation are identifies by field observations and by remotely sensed data. Boundaries are verified at closely spaced intervals.	0.6 to 4	Phases of soil series, miscellaneous areas, few named at a level above the series.	Consociations, complexes; few associations and undifferentiated groups.	1:12,000 to 1:31,680
3rd order - Extensive (i.e., range or community planning.)	Soil boundaries plotted by observation and interpretation of remotely sensed data. Soil boundaries are verified by traversing representative areas and by some transects.	1.6 to 16	Phases of soil series or taxa above the series; or miscellaneous areas.	Mostly associations or complexes, some consociations and undifferentiated groups.	1:20,000 to 1:63,360
4th order - Extensive (e.g., general soil information for broad statements concerning land-use potential and general land management.)	Soil boundaries plotted by interpretation of remotely sensed data. Boundaries are verified by traversing representative areas and by some transects.	16 to 252	Phases of soil series or taxa above the series or miscellaneous areas.	Mostly associations; some complexes, consociations and undifferentiated groups.	1:63,360 to 1:250,000
5th order - Very extensive (e.g., regional planning, selections of areas for more intensive study.)	The soil patterns and composition of map units are determined by mapping representative ideas and like areas by interpretation of remotely sensed data. Soils verified by occasional onsite investigation or by traversing.	252 to 4,000	Phases of levels above the series, miscellaneous areas.	Associations; some consociations and undifferentiated groups.	1:250,000 to 1:1,000,000 or smaller

[1]This is about the smallest delineation allowable for readable soil maps (see Table 2-2). In practice, the minimum-size delineations are generally larger than the minimum-size shown.

[2]Where applicable, all kinds of map units (consociations, complex, associations, undifferentiated) can be used in any order of soil survey.

Mapping legends are designed to provide the degree of refinement of map units required by the objectives of the survey. A map unit can be identified as a consociation (an area dominated by a soil of a single taxon such as a series or a suborder) or as a group (geographic mixture) of taxa, such as associations or complexes. A group may be more heterogeneous, and less refined, than a consociation at the same level of classification. A soil series has a much more narrowly defined set of soil properties than a suborder; and, therefore, it is a more refined distinction. Thus, phases of soil series are used as map units if users need more precise information about small areas of soils. Phases of any category in *Soil Taxonomy* might be used as soil map units if a very broad perspective of the soil resources of very large areas is needed.

Standards of *purity* are adjusted according to the precision required by the survey objectives. Probably all delineations contain some kinds of soil besides that identified in the map unit name. These inclusions reduce purity. Different kinds of inclusions, however, have different effects on the value of the map for use. The inclusions that most detract from purity are those that are distinctly more limiting for use than the named soil. These are called limiting dissimilar soils. Not only the amount of such limiting soils but also the size of their individual areas is important. Soil survey standards for both are set at levels that do not seriously detract from the validity of interpretations based on the named soil.

Standards of purity are attained by adjusting the field operations. If the standards require that areas of limiting dissimilar soils as small as 0.1 ha be delineated, for example, the area must be traversed at intervals close enough to find areas that small and the soil must be examined at enough places along each traverse to detect them.

The *map scale* must be large enough to allow areas of minimum size to be delineated legibly. Figure 2-4 illustrates the effect of scale on legibility of maps.

The choice of map scale also depends on the perspective of the user. Users who need precise information about small areas focus their attention on a small part of the map and on a relatively few delineations. They are not distracted by boundaries and symbols on other parts of the map. Consequently, the map scale can be the smallest that will permit legible delineation of the pertinent areas.

Map users who want a broad perspective of large areas, however, are usually concerned with comparisons among delineations of all, or a large part, of the map. Consequently, delineations on maps for such uses are generally larger and fewer in number.

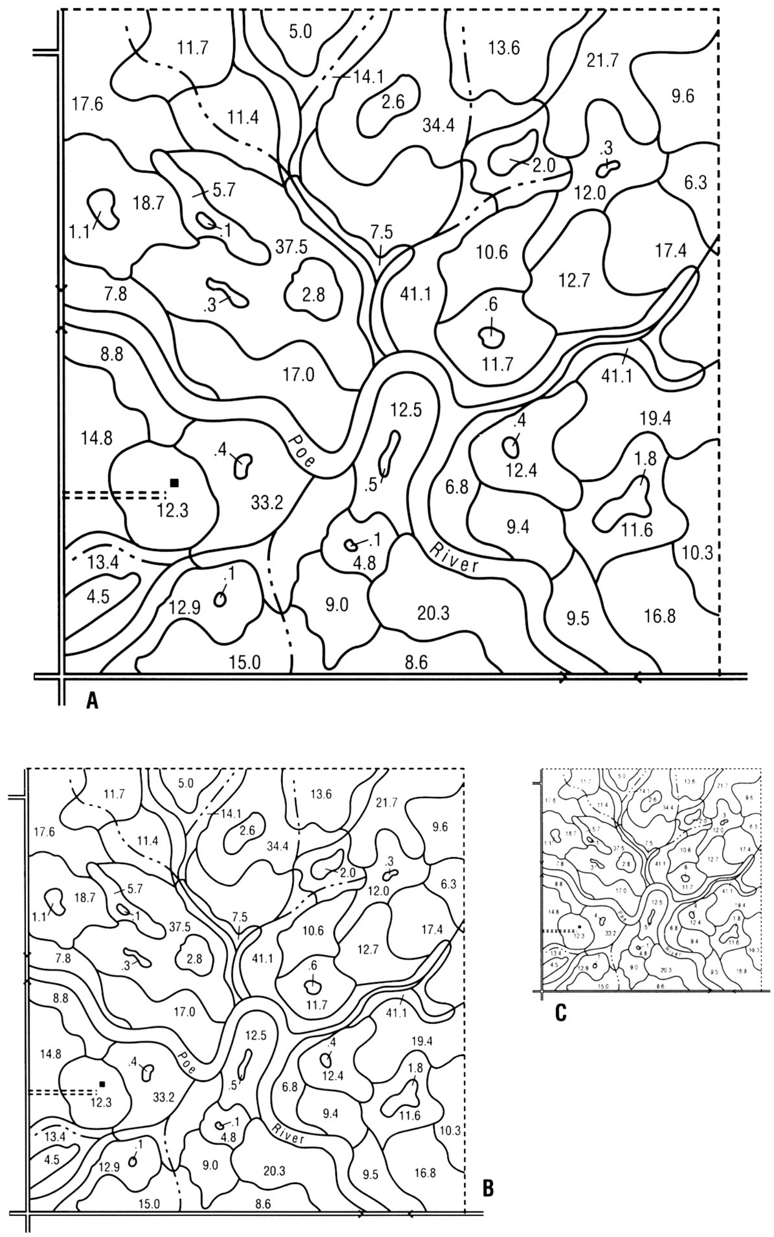
Table 2-2 shows the relationships between map scales and the smallest delineations that can be made legibly at those scales. The difference between the smallest delineation that could be made and the smallest that is commonly made increases as map scale decreases.

The order of a survey is a consequence of field procedures, the minimum size of delineation, and the kinds of map units that are used. Table 2-1 is a key for identifying orders of soil surveys.

First-order surveys are made for very intensive land uses requiring very detailed information about soils, generally in small areas. The information can be used in planning for irrigation, drainage, truck crops, citrus or other specialty crops, experimental plots, individual building sites, and other uses that require a detailed and very precise knowledge of the soils and their variability.

Field procedures permit observation of soil boundaries throughout their length. The soils in each delineation are identified by traversing and transecting. Remotely sensed data are used as an aid in boundary delineation. Map units are mostly consociations with few complexes and are phases of soil series or are miscellaneous areas. Some map units named at a categorical level above the series may be appropriate. Delineations have a minimum size of about 1 hectare (2.5

FIGURE 2-4



Copies of the same map at different scales: A, 1:21,120; B, 1:31,680; C, 1:63,360 (equivalent to 3, 2, and 1 inch equals one mile, respectively). The numbers within individual delineations are the acreages of the areas represented (1 acre equals 0.40 hectares).

acres) or less, depending on scale, and contain a minimum amount of contrasting inclusions within the limits permitted by the kind of map unit used. Base map scale is generally 1:15,840 or larger.

Second-order surveys are made for intensive land uses that require detailed information about soil resources for making predictions of suitability for use and of treatment needs. The information can be used in planning for general agriculture, construction, urban development, and similar uses that require precise knowledge of the soils and their variability.

Table 2-2. Guide to Map Scale and Minimum Delineation Size

Map scale	Inches per mile	Minimum size delineation[1] acres	hectares
1:500	126.7	0.0025	0.001
1:2,000	31.7	0.040	0.016
1:5,000	12.7	0.25	0.10
1:7,920	8.00	0.62	0.25
1:10,000	6.34	1.00	0.41
1:12,000	5.28	1.43	0.57
1:15,840	4.00	2.5	1.0
1:20,000	3.17	4.0	1.6
1:24,000 (7 1/2')	2.64	5.7	2.3
1:31,680	2.00	10.0	4.1
1:62,500 (15')	1.01	39.0	15.8
1:63,360	1.00	40.0	16.2
1:100,000	0.63	100.0	40.5
1:125,000	0.51	156.0	63.0
1:250,000	0.25	623.0	252.0
1:300,000	0.21	897.0	363.0
1:500,000	0.127	2,500.0	1,000.0
1:750,000	0.084	5,600.0	2,270.0
1:1,000,000	0.063	10,000.0	4,000.0
1:5,000,000	0.013	249,000.0	101,000.0
1:7,500,000	0.0084	560,000.0	227,000.0
1:15,000,000	0.0042	2,240,000.0	907,000.0
1:30,000,000	0.0021	9,000,000.0	3,650,000.0
1:88,000,000	0.0007	77,000,000.0	31,200,000.0

[1] The "minimum size delineation" is taken as a 6-mm square area (1/16 sq. in.). Cartographically, this is about the smallest area in which a symbol can be printed readily. Smaller areas can be delineated, and the symbol lined in from outside; but such small delineations reduce map legibility. On maps at the smaller scales, delineations are commonly 1 1/2 to 2 times the size of the minimum area that can be shown.

Field procedures permit plotting of soil boundaries by observation and by interpretation of remotely sensed data. Boundaries are verified at closely spaced intervals, and the soils in each delineation are identified by traversing and in some map units by transecting. Map units are mostly consociations and complexes. Occasionally undifferentiated groups or associations are also used. Components of map units are phases of soil series or phases of miscellaneous areas; map units named at a categorical level above the series can be used. Delineations are variable in size with a minimum of 0.6 to 4 hectares (1.5 to 10 acres), depending on landscape complexity and survey objectives. Contrasting inclusions vary in size and amount within the limits permitted by the kind of map unit used. Base map scale is generally 1:12,000 to 1:31,680, depending on the complexity of the soil pattern within the area.

Third-order surveys are made for land uses that do not require precise knowledge of small areas or detailed soils information. Such survey areas are usually dominated by a single land use and have few subordinate uses. The information can be used in planning for range, forest, recreational areas, and in community planning.

Field procedures permit plotting of most soil boundaries by observation and interpretation of remotely sensed data. Boundaries are verified by some field observations. The soils are identified by traversing representative areas and applying the information to like areas. Some additional observations and transects are made for verification. Map units include associations, complexes, consociations, and undifferentiated groups. Components of map units are phases of soil series, taxa above the series, or they are miscellaneous areas. Delineations have a minimum size of about 1.6 to 16 hectares (4 to 40 acres), depending on the survey objectives and complexity of the landscapes. Contrasting inclusions vary in size and amount within the limits permitted by the kind of map unit used. Base map scale is generally 1:20,000 to 1:63,360, depending on the complexity of the soil pattern and intended use of the maps.

Fourth-order surveys are made for extensive land uses that need general soil information for broad statements concerning land-use potential and general land management. The information can be used in locating, comparing, and selecting suitable areas for major kinds of land use, in regional land-use planning, and in selecting areas for more intensive study and investigation.

Field procedures permit plotting of soil boundaries by interpretation of remotely sensed data. The soils are identified by traversing representative areas to determine soil patterns and composition of map units and applying the information to like areas. Transects are made in selected delineations for verification. Most map units are associations, but some consociations and undifferentiated groups may be used in some surveys. Components of map units are phases of soil series, of taxa above the series, or are miscellaneous areas. Minimum size of delineations is at least 16 to 252 hectares (40 to 640 acres). Contrasting inclusions vary in size and amount within the limits permitted by the kind of map unit used. Base map scale is generally 1:63,360 to 1:250,000.

Fifth-order surveys are made to collect soils information in very large areas at a level of detail suitable for planning regional land use and interpreting information at a high level of generalization. The primary use of this information is selection of areas for more intensive study.

Field procedures consist of mapping representative areas of 39 to 65 square kilometers (15 to 25 square miles) to determine soil patterns and composition of map units. This information is then applied to like areas by interpretation of remotely sensed data. Soils are identified by a few onsite observations or by traversing. Most map units are associations, but some consociations and undifferentiated groups may be used. Components of map units are phases of taxa at categorical levels above the series and miscellaneous areas. Minimum size of delineations is about 252 to 4,000 hectares (640 to 10,000 acres). Contrasting inclusions vary in size and amount within the limits permitted by the kind of map unit used. Base-map scale ranges from about 1:250,000 to 1:1,000,000 or smaller.

Two Orders of Soil Survey in the Same Project

Some soil survey areas have two or more separate and distinct parts that have different needs. For example, one part may be mapped to make predictions that pertain to irrigation, but the other may be mapped to make predictions that relate to range management. The irrigated part should be mapped at the intensity required for a second-order soil survey, and map units are mostly consociations of narrowly defined phases of soil series. The part used for grazing, however, can be mapped as a third-order survey and uses associations, complexes, and some consociations of more broadly defined phases of soil series or of taxa above the series. Some map units of the two parts will consist of the same kinds of soil, but great care is exercised to ensure that map units for the two different orders of soil survey maps do not have the same names or symbols.

Large, separate, and distinct areas that are within the same project but surveyed by different methods should be distinguished clearly by boundaries on the published soil map or on a small-scale inset map. Each part is identified by a note printed parallel to the line separating the areas of each survey order. The two parts have separate legends. The parts are considered as distinctly different orders of soil survey, but the results are reported in the same publication. The same or different map scales may be used for the different survey orders, depending on the intended uses.

Many 2nd-order surveys delineate some map units by methods that are less intensive, even though the areas mapped at different intensities are intermingled on the map. For example, within an otherwise detailed soil map, the delineations of very steep or very stony soils are commonly investigated at the intensity normally used in a third-order survey. This is discussed in soil survey procedures.

Still other soil surveys include areas consisting of two or more distinctive soils that could be mapped separately by detailed soil survey methods; however, the cost of making the separation cannot be justified. For example, a survey area that is mostly productive soils suitable for general farming may contain large areas of unproductive sandy soils covered with thick brush. Although the sandy areas contain contrasting kinds of soil that could be delineated separately, the cost of detailed mapping to separate the two kinds of soils may exceed the expected return. The outer boundaries of the sandy areas are plotted in as much detail and with as careful investigations as any other boundaries of the soil survey, but the sandy areas themselves are mapped by third- or fourth-order methods. Traverses are made, and the composition of the areas is defined in terms of the kinds, proportions, and patterns of the individual soils. The delineations are described in the text of the published soil survey as soil associations mapped by methods of the appropriate survey order.

Soil Maps Made by Other Methods

Although most soil maps published in the United States by the National Cooperative Soil Survey are made by field investigations, some are compiled from other sources. These kinds of soil maps are described in the following sections.

Generalized Soil Maps

Some users need soils information about areas larger than individual fields or tracts, as large as perhaps several square kilometers, but a detailed map tends to obscure the broad relationships. Generalized soil maps are made to reveal geographic relationships that cannot be seen readily on detailed maps. Most soil survey reports include a general soil map for the area. The scale of these maps depends on the intended uses.

Generalized soil maps are made by combining the delineations of existing soil survey maps to form broader map units. Scrutiny of a detailed map usually will find large areas in which a few soil series, commonly two or three, are consistently associated. A detailed map is generalized by enclosing those larger areas within which a few kinds of soil predominate in relatively consistent proportions and patterns. These larger areas are described in terms of the dominant soils. The map is interpreted to show the combined effects of the constituent soils of each map unit.

Some of the possible uses for generalized soil maps are for appraising the basic soil resources of whole counties, for assisting farm advisors in the geographic emphasis of their educational programs, and for guiding commercial interests. Increasingly, these maps are compiled for county and regional land-use planning. Other possible uses include predicting the general suitability of large areas of soils for residential, recreational, wildlife, and other nonfarm uses, as well as for agriculture. Suggesting alternative routes for roads and pipelines where the least problems with soils are expected is also a potential use. The information in generalized soil maps may be useful as one basis for zoning.

Soil maps that are already less detailed can be generalized further for purposes that require very broad perspective. For example, 4th-order soil surveys for individual counties at scales of less than 1:250,000 can be combined and generalized to provide maps of States or regions at a scale of 1:1,000,000 or smaller. Soil maps that show the soils of areas of a few square kilometers can be converted to maps having delineations of a few hundred square kilometers, or more. Areas defined as associations of soil series or their phases are combined in this process into larger areas that can be defined in terms of associations of taxa at higher categories. These broad soil associations can be divided into phases to specify ranges in physiography, soil texture, or other features if such distinctions are useful. Soil maps at such levels of abstraction are designed for very broad regional planning and other uses that focus on areas of hundreds of square kilometers.

Schematic Soil Maps

Schematic soil maps are also compiled, but they differ from generalized soil maps in being compiled from information other than pre-existing soil maps. Scale is commonly 1:1,000,000 or smaller, although useful maps are sometimes made at larger scales. Schematic soil maps are commonly made as a preliminary step to locate areas where further investigation is justified. For many areas, especially in undeveloped regions, a schematic soil map is useful in advance of an organized field survey. Some maps serve as the only source of soils information in areas where more intensive studies are not feasible.

Schematic soil maps are made by using many sources of information to predict the geographic distribution of different kinds of soil. First, all available data are assembled. Information about climate, vegetation, geology, landforms, and other factors related to soil are gathered and studied. Data obtained by remote sensing techniques, including aerial photography, may provide useful information. Any available information about the soil is used to the extent justified by its quality. Some soils information exists for most parts of the world, but in wild areas the information may be mainly notes by travelers and rough maps interpreted from aerial photographs without verification on the ground.

Schematic soil maps merge with 5th-order (exploratory) soil surveys without a sharp line of distinction.

A soil is the unique result of five interrelated factors: *climate* and *living organisms*, conditioned by *relief (topography)*, acting on parent material for periods of time. If good geographic data about these factors are available, good soil maps can be compiled by experienced soil scientists who are familiar with the combinations of factors that produce the different kinds of soils. The amount of detail and verification by field investigation depends upon the purpose and intended use of the soil survey.