CHAPTER 5
Application of Soil Taxonomy to Soil Surveys

The fundamental purposes of a soil survey are to show the geographic distribution of soils and to make predictions about the soils (USDA, SCS, 1951 and 1993). To this end, a soil survey includes soil maps, map unit descriptions, soil series descriptions, taxonomic classifications, and interpretations for the use and management of the soils.

Soil surveys are made at several intensities and for many uses. The procedures, standards, and uses are described in the most recent revision of the Soil Survey Manual (USDA, SCS, 1993) and the most recent version of the National Soil Survey Handbook (USDA, NRCS, 1997). The applications of soil survey are numerous. They include interpretations for the growth of plants, such as crops, forage species, trees, and ornamental shrubs. They also include interpretations for urban, rural, and recreational development and for conservation and wildlife habitat planning.

Soil mapping and classification have evolved, and the conceptual framework for mapping and classifying soils has changed and will continue to change. Over the years soil science literature has documented numerous concepts and approaches to mapping, classifying, and interpreting soils at various scales. The purpose of this chapter is not to present the numerous concepts and approaches but to outline the application of widely used and accepted soil-landscape models and taxonomic models for mapping and labeling soil geographic order in soil surveys at scales of 1:12,000 to 1:100,000 and in soil surveys at scales smaller than 1:100,000.

Mapping and Labeling Soil Geographic Order at Large (1:12,000 to 1:31,680) and Intermediate (1:31,680 to 1:100,000) Scales

Mapping Soil Geographic Order

A landscape is a portion of the land surface that the eye can comprehend in a single view and is a collection of landforms (Ruhe, 1969). Understanding landscapes and landforms and their influence on soil distribution is critical in observing and mapping soil geographic order (Peterson, 1981; Ruhe, 1969). The tasks of a soil scientist who sets out to map soils and produce a soil survey are to perceive a meaningful soil geographic pattern at the landscape, landform, and landform component levels and to record that pattern in a form that can be retained and conveyed to others. The most common scales for a large-scale soil map range from 1:12,000 to 1:31,680 (USDA, SCS, 1993). With intensive field investigation of areas mapped within this scale range, soil geographic variation can be readily observed and recorded cartographically at the landscape, landform, and landform component levels. The minimum-size delineation is commonly between 0.6 and 4 ha (USDA, SCS, 1993).

Intermediate-scale soil maps range from 1:31,680 to 1:100,000 and are commonly associated with lower intensity field soil surveys (USDA, SCS, 1993). At this map scale and with the lower intensity of field investigation, soil geographic variation can be observed and recorded cartographically at the multiple landscape, landscape, or landform level. The minimum-size delineation for intermediate soil maps is commonly between 4 and 250 ha (USDA, SCS, 1993).
In mapping soils at any scale, it is necessary to assume that there is a pattern of order in the spatial distribution of soil characteristics. The soil genesis model, which defines soil as a function of parent material, climate, living organisms, relief, and time, provides a basis for predicting order. A soil surveyor quickly learns that the geographic distribution of soils is related to the five soil-forming factors. A soil surveyor observes and maps a geographic pattern of soils by grouping soils with similar genesis and by separating soils where there is a change in one or more of the soil-forming factors. Hudson (1990 and 1992) outlined the application of the catena concept (Milne, 1936) and the soil factor equation (Jenny, 1941) to soil survey as a general model of perceiving and mapping soil geographic order. Hudson (1992) has also summarized the soil-landscape paradigm that has guided field soil surveys in the United States for almost a century.

The Soil-Landscape Paradigm and Soil Survey

Soils are landscapes as well as profiles (USDA, SCS, 1951, pp. 5-8; USDA, SCS, 1993, pp. 9-11). In soil survey, a soil-landscape unit can be thought of as a landscape unit (landscape, landform, or landform component) further modified by one or more of the soil-forming factors. Within a soil-landscape unit, the five factors of soil formation interact in a distinctive manner. As a result, areas of a soil-landscape unit have a relatively homogeneous soil pattern. A soil surveyor perceives soil patterns by first conceptually dividing the landscape into soil-landscape units. The boundaries between dissimilar soil-landscape units are placed where one or more of the soil-forming factors change within a short lateral distance. The more rapid the change between one or more of the soil-forming factors, the more abrupt the boundary between the soil-landscape units and the easier it is for one to locate the boundary. The slower the change between one or more of the soil-forming factors, the more gradual the boundary between the soil-landscape units and the more difficult it is for one to locate the boundary. Generally, the closer the similarities between two landscape units, the more gradual the change between the landscape units and the more similar their associated soils tend to be. Conversely, very dissimilar landscape units tend to have abrupt boundaries between them and have very dissimilar soils.

Identifying soil-landscape units provides the basis for recognizing soils and then designing soil map units, which are the basic units for identifying soil geographic order in a soil survey. Soil-landscape units can be combined to form map units that encompass broader ranges of soils, or subdividing the soil-landscape units can identify the soils and soil distribution within a map unit in greater detail. The degree to which soil-landscape units are combined or subdivided to form soil map units is primarily a function of the complexity of the soil-landscape units, the detail required for the intended use of the soil survey, and the ability of the soil scientist to consistently identify the soils and map units through application of the available knowledge and tools and within the constraints of cost and time.

Labeling Soil Geographic Order With Soil Taxonomy

A soil delineation (soil map unit delineation) is an individual polygon identified on a soil map by a map unit symbol and/or name that defines a three-dimensional soil body of a specified area, shape, and location on the landscape (Soil Science Society of America, 1997). A map unit is an aggregate of all soil delineations in a soil survey area that have a defined set of similar soil characteristics (Van Wambeke and Forbes, 1986).

Once soil-landscape units and soil map units have been delineated, some means of labeling and representing the kinds of soil that occur in the map units is needed. The classification system described in Soil Taxonomy (USDA, SCS, 1975) has been used for many years in identifying and labeling soils that occur within soil-landscape units and soil map units. Following is a description of the application of the taxonomic system to soil survey.

A class is a group of individuals or other units similar in selected properties and distinguished from all other classes of
the same population by differences in these properties. Taxon
(\textit{pl. taxa}) is a name used in classifications for a single class. It
may be broadly or narrowly defined according to the category.
A soil order is a taxon, as is a soil series, a family, or a great
group (Smith, 1963). The taxa of this soil classification are
conceptual and are defined as precisely as our present
knowledge permits. They give us common standards for soil
correlation, which includes the mapping, naming, and
interpretation of soils. In practice, soil scientists map soil-landscape
units. Properties of these soil-landscape units
correspond to the concepts of the taxa. Relating the soil bodies
(soil-landscape units or soil delineations) represented on maps
to taxonomic classes at some level in a classification system is
accomplished through soil correlation (Simonson, 1963).

In large- and intermediate-scale soil surveys, if the concept of
a named series or other taxon corresponds to the properties of
the soil expected in a soil-landscape unit or soil map unit, we
normally use the name of that series or taxon to help identify the
soil properties of the delineation. If there is no named series or
taxon available and we believe that such a series or other taxon
would be useful, we define and establish a new series or other
taxon. Also, for the practical purposes of a soil survey, another
classification is superimposed on the series or taxa to identify
significant differences in slope, erosion, stoniness, or other
characteristics. The assignment of taxonomic names, such as the
name of a soil series, to label a map unit means that if we examine
the soil-landscape unit or soil map unit, we expect most
locations within the delineation to meet the criteria of the taxon
or taxa (Holmgren, 1988). The designing, naming, and describing
of soil map units, which are covered elsewhere (USDA, SCS,
1993; USDA, NRCS, 1997; Van Wambeke and Forbes, 1986), are
all critical elements in the understanding of soil geographic
patterns.

\textbf{Soil Geographic Order and Soil Taxonomy in Soil Survey}

It is commonly acknowledged that there is a disparity
between the entity that soil surveyors map and the entity that
they classify. Soil surveyors map soil bodies (soil-landscape
units and soil map units). Soil taxonomy, however, effectively
utilizes properties from samples taken within the soil-landscape
units and soil map units to establish taxon
boundaries and classify soils (Holmgren, 1988). Time and the
fiscal constraints of a soil survey necessitate minimizing the
number of samples taken. In the past, this disparity between
sampling units and mapping units and the need for minimizing
the sampling effort was rationalized with the pedon and
polypedon. The pedon served as the sampling unit and was
deefined as a three-dimensional soil volume with an area of 1 to
10 m$^2$ and a depth that includes the entire solum (USDA, SCS,
1975). The polypedon was defined as a set of contiguous
pedons (USDA, SCS, 1975). It was intended to be used to
establish series level taxa and the map units delineated in the
soil survey.

Applying the pedon and polypedon concepts to mapping
and classification has been the subject of debate and a source of
misunderstanding in soil survey for decades (Hudson, 1990 and
1992; Holmgren, 1988). Some notable problems are that in
reality soil profiles rather than pedons (i.e., three-dimensional
volumes) are really sampled and classified (Holmgren, 1988),
that soil property variation prohibits the selection of one profile
or a few profiles to represent variation within delineated soil
bodies (Hudson, 1990), and that soil-landscape units and soil
map units are composed of more than one polypedon (as
defined by USDA, SCS, 1975) and contain soils with properties
outside the ranges of established taxa. Application of the soil-landscape
paradigm (Hudson, 1990 and 1992), however, can
identify soil-landscape boundaries and soil map unit boundaries,
and then, through careful selection of soil profiles that best
represent soil conditions within soil-landscape and soil map unit
delineations, the soil map units can be labeled and described
and useful soil surveys can be produced.

Large- and intermediate-scale soil surveys can be used to
provide general information about soil properties within each
soil-landscape unit and soil map unit. These soil surveys,
however, cannot be used in predicting exact soil properties at
any particular location with statistical confidence, and soil
properties may exceed the ranges defined for the taxa used to
represent soil-landscape units and soil map units.

**Recognizing Established Series and Establishing New Series in a Soil Survey Area at Scales of 1:12,000 to 1:100,000**

The standards for establishing series, recognizing established series, and naming the map units within a soil survey area have changed in the past and can be expected to change in the future. The current standards are presented elsewhere (USDA, SCS, 1993; USDA, NRCS, 1997; Van Wambeke and Forbes, 1986), and the results of the various international classification committees are readily available. The factors that should be considered when recognizing established soil series, establishing new soil series, and naming the map units within a soil survey area are described in the following paragraphs.

The soil series is the basic taxonomic class in soil survey areas mapped at large and intermediate scales. As a taxonomic class, a series is a group of soils that have horizons similar in arrangement and in differentiating characteristics (USDA, SCS, 1993). When recognizing established series and establishing new series in the field, we must consider the scale and the degree of accuracy and precision at which we observe and plot boundaries between soil-landscape units and soil map units. We must also consider the ability of soil scientists to consistently observe, determine, and record soil similarities and differences in the field; the purpose of the soil survey; the nature of the variability of the soils within a delineation; the importance of the variations to planning; and the probable uses of the soils. An example of the application of series differentiae is given in chapter 21 of this publication.

The representation of soil distribution on a map is imperfect to varying degrees. In the field, at large and intermediate scales, soil scientists observe the boundaries between soil landscape units and soil map units and then record the boundaries on an aerial photo or an appropriate map base. Inevitably, there are errors in the observation and placement of these lines, in the sampling and identification of soils at the boundaries, and in the sampling and identification of soils within the boundaries of soil-landscape units and soil map units.

Because series have narrow ranges in their properties, most soils within a soil-landscape unit or soil map unit can be sampled and identified with reasonable accuracy, even though the locations of some of the boundaries may be obscure or difficult to place. There commonly are areas in which a soil in a delineation does not fit an established series. In this case the range in characteristics of the existing series could be expanded, a new series could be established, or the soil could be handled as a taxadjunct (USDA, SCS, 1993; Van Wambeke and Forbes, 1986). There are also cases in which soils within a soil-landscape unit or soil map unit occur as areas too small or too intermingled to be delineated at the selected scale or in which differences between soils are subtle and cannot be consistently observed and mapped in the field. These cases can be handled within the definitions of kinds of soil map units, which include consociations, complexes, associations, and undifferentiated groups, and in the map unit descriptions (USDA, SCS, 1993; Van Wambeke and Forbes, 1986).

**Labeling Soil Maps at Scales Smaller Than 1:100,000**

As map scales become smaller, the degree of detail and precision of the soil map decreases. This decrease is reflected in the naming of map units and in the map unit descriptions. Small-scale or general soil maps of individual survey areas in published soil surveys in the United States commonly have scales that range from about 1:100,000 to 1:250,000. The map units delineated on these maps have been named as associations of series. These generalized maps usually are made by combining the delineations of detailed soil survey maps to form broader map units (USDA, SCS, 1993). These broader map units group similar map unit delineations and are commonly named for the two or three most dominant soil series or taxa. The map unit descriptions for these smaller scale maps should reflect the greater degree of map generalization.
State and regional soil maps commonly are produced at scales of 1:250,000 to 1:1,000,000. State and regional general soil maps can be produced by further generalizing county soil maps. These state and regional maps are typically at scales of about 1:500,000, and the map units delineated on these maps are associations of the dominant soil series or taxa on the county general soil maps.

Schematic soil maps commonly are at a scale of 1:1,000,000 or smaller (USDA, SCS, 1993). These maps can be compiled from information on more detailed soil maps, county and state general soil maps, and regional soil maps. Other sources of soil geographic information can also be used where little or no soil mapping information is available. At these small scales, map units commonly are associations or consociations of taxa at the higher categories, such as Oxisols, Udalfs, and Epiaquepts.

**Literature Cited**