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Ranges of Characteristics—How Valid are They

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Introduction

Writing pedon descriptions in the course of mapping is a substantial part of the soil survey program. Data resulting from these descriptions are the basis for our quality control activities—what we call the correlation process. A major objective of this process is to insure that the relationship between each map unit and its reference taxonomic unit is valid. In addition, the data are used to develop a range of characteristics for the reference taxon and to select a local typifying pedon.

Describing representative pedons in each map unit is a necessity. We must verify that pedons representative of the reference taxon are commonly present in the map unit. This is essential data for correlation. However, deriving a local range of characteristics and publishing this material in the soil survey cannot be justified in such simple utilitarian terms. This activity in its entirety is not essential for the proper correlation of soil surveys.

Origin of this Procedure

In the early days of the soil survey there was no way of knowing what the range of characteristics for a taxonomic unit, including the series, should be. At that time soil classification was, by necessity, non-quantitative. Little was known about the wide range of soil conditions present on America's landscape. Throughout the years voluminous data have been collected detailing the physical and chemical properties of soil profiles representing every region of the country. One major goal of this empirical process was to formulate modal concepts for soil series to be used as reference taxa in the soil survey. In each soil survey, an attempt was made to locate and describe a local modal profile for each taxon used. One result of this local research was the development of firm, narrow series concepts as more and more areas were surveyed.

Ultimately, this process resulted in a quantitative soil classification system. With the development of *Soil Taxonomy* the limits of characteristics for taxa, including series, were specified in terms of measurable soil

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properties. The allowable range of most characteristics for series used as reference taxa now are narrowly delimited by *Soil Taxonomy*, which has been constructed from years of observation.

Why the Present Procedure is Continued

Developing and publishing local ranges of characteristics is no longer necessary to develop a modal series concept for most well established series. This has already been accomplished. Why, then, do we continue to do it? I believe we continue this process because of a viewpoint or set of assumptions which, although unproven, are shared by many soil scientists. It is commonly believed that the total range of characteristics which define a soil series is somehow directly related to the total extent of pedons on the face of the earth which are representative of that series. For example, if a soil series is mapped on the southeastern Coastal Plain from Virginia to Texas, it is widely assumed that the total range of allowed variation within the series could be observed only by examining representative pedons throughout this broad geographic range. It is further assumed that when dealing with a small part of the geographic range, one is, by necessity, dealing with a narrower taxonomic range. Based on this assumption, we use pedon descriptions to determine what we think is the typical pedon for the survey area and the local range of characteristics we think this taxonomic unit has.

Origin of These Assumptions

Assumptions so widely accepted and having such a great influence on soil survey activities must have some rational foundation. These assumptions can be traced back to ideas which originated early in the history of soil science. Around 1900, Dokuchaev found that certain soil properties such as the humus content of Chernozems changed gradually over the surface of the earth with changes in temperature and moisture conditions. Jenny, in his well known book, illustrated that depth of carbonate deposits in some American soils showed the same type of broad climatic or zonal influence. Similar correlations were noted for other soil properties, such as the amount and type of weatherable minerals.

Inferences from observations such as these led to the formulation of the zonal soil concept. Basic to this concept is the idea that certain soil properties are well correlated with broad climatic-vegetation zones. This zonal soil concept is a valid one. Certain kinds of soils do occur in broad bands reflecting large scale climatic and vegetational influences. For example, the geographic distribution of soils having properties definitive for Mollisols, Aridisols, and Ultisols in the United States is well correlated with broad climatic-vegetational influences.

An important point must be made, however. This relationship between soil properties and large geographic areas can be assumed to exist only for those profile characteristics which are themselves reflections of large scale climatic-vegetational influences. It does not necessarily exist for all profile characteristics used as differentiae at all levels of taxonomy.

Development of Soil Series as Taxonomic Units

In this country we have been making large scale soil maps for years. These maps are used for developing detailed management plans and for making specific management decisions. As a result, we need maps that reflect rather small variations in soil conditions. For example, we commonly separate areas of soil which are predominantly well drained from those that are mostly moderately well drained. We try to separate areas of soils which have mostly arenic surfaces from those that have predominantly typic surfaces. To make maps showing such small variations in the soil cover we have developed a reference taxon which was very narrowly defined in terms of allowable profile characteristics.

In addition to being a very narrowly defined unit, our reference taxon has another important property. This becomes evident if one considers how we make detailed soil maps. We delineate areas of soil based on differences in topographic position, steepness of slope, type of vegetation, surface color, and other non-taxonomic features. We then examine sample pedons within each delineated area to assign the name of a taxonomic unit to it. In order to do this consistently, we developed a reference taxon defined in terms of profile characteristics which are very sensitive to small changes in local soil forming factors.

The narrowly defined soil series evolved as the taxon of choice for detailed mapping. This taxon is useful because, over the years, we have defined it in terms of soil properties which vary abruptly in response to changes in topography, slope, water table depth, and other local factors of soil formation. That is, soil series generally are designed to appear and disappear abruptly on small areas of the landscape as a result of various changes in the local environment. That is why they are so mappable.

This leaves us in a somewhat contradictory position. We have designed soil series with very narrow allowable ranges. These ranges are defined using profile characteristics which are extremely responsive to small changes in local factors of soil formation. However, we still believe that the profile characteristics used to separate series are largely controlled, not by these same local soil forming factors, but by broad scale geographic influences such as climate. No one has proven that there is a correlation between the characteristics used to delimit series and the distribution of pedons on the face of the earth which have those characteristics. We have blindly applied a concept, valid for certain criteria used at high levels of taxonomy, to a set of criteria and taxa at a lower level where they may be totally inappropriate.

The idea that soil characteristics which define series are completely manifested only over the entire geographic extent of the series has not been seriously examined. It has merely been assumed that such a situation prevails. Although this assumption is considered axiomatic, I believe it is fallacious. Based on this discussion, I maintain that the following assumption is far more logical:

We have deliberately defined soil series in terms of profile characteristics which are very sensitive to changes in local soil forming factors.

Furthermore, they are defined very narrowly so that they can be used as reference taxa in separating areas of soils with small morphological differences. This implies that the narrow range of characteristics used to define a soil series are probably multicyclic on the landscape. That is, the total allowable range of characteristics is replicated again and again in small areas within the geographic extent of the series.

One question immediately comes to mind. If, as I suggest, the entire range of characteristics for most soil series is replicated many times within areas smaller than those dealt with in progressive soil surveys, why haven't our pedon descriptions indicated this? There are two reasons why. First, our sampling intensity is extremely low. Second, we try to estimate the limits of our local taxons by making inferences from data taken entirely from within each class under consideration. To properly estimate the limits of several classes in a population, one must make comparisons among classes. Examples will help to illustrate these points.

When we derive a range of characteristics for a soil series used as a taxonomic unit in a soil survey area, we actually are attempting to characterize our local pedon population. We begin with the prior assumption that our local pedon population has a narrower range of characteristics than the parent population. We then sample the local population to determine what this narrow local range is. The pedon, which is the basic taxonomic sampling unit, ranges from 1 to 10 sq. m. in size, depending upon the variability of soil horizons. Let's assume that the average pedon representative of a given taxonomic unit is 10 sq. m. in size. Next, assume that pedons representative of that taxonomic unit occupy 10,000 acres in the soil survey area. Now compute the size of the local pedon population as follows:

10 sq. m./pedon = 107.6 sq. ft./pedon
10,000 acres = 435,600,000 sq. ft.
pedon population = 435,600,000/107.6 sq.ft.·per pedon
4,048,327 pedons

If, in the course of a soil survey, we write 200 pedon descriptions representative of the taxonomic unit, our sampling intensity can be computed as follows:

20/4,048,327 = 0.00049%

We are closely observing and making detailed descriptions of only five pedons out of every 10,000 and making inferences about our local population. At this level of sampling, we usually find the narrower range of characteristics we are looking for. However, we take additional precautions to make certain that our local range of characteristics is narrower than the series range. We do this by arbitrarily restricting our inferences to only those data which fall within the allowable range of the series. In other words, we try to characterize the outer limits of a class by making observations only within that class. No comparisons among classes are made.

For example, in the Cumberland-Hoke survey in North Carolina the Norfolk series is used as a reference taxon. The family classification of this series is Typic Paleudult, fine loamy, siliceous, thermic. This taxonomic placement largely determines the allowable ranges of most important profile characteristics. For example, a representative pedon of the Norfolk

series must have the following characteristics:

Thickness of A horizon	less than 20 in.
Subsoil depth	greater than 60 in.
Texture of control section	18 to 35% clay, less than 30% silt
Depth to gray mottles	more than 30 in.
Depth to layer with more than 5% plinthite	greater than 60 in.

There are similar series which differ from Norfolk only in having a redder subsoil, so the allowable subsoil hue for the series is 2.5Y through 7.5YR.

In the Cumberland-Hoke survey we use a number of series with ranges which compete with Norfolk. For example, we use the Wagram series (sandy surface thicker than 20 in.), the Faceville series (redder, more clayey subsoil), the Orangeburg series (redder subsoil), the Goldsboro series (gray mottles above 30 in.), the Lucy series (redder subsoil, sandy surface thicker than 20 in.), the Rumford series (thinner, less clayey subsoil), and the Dothan series (more than 5% plinthite in a layer within 60 in. of the surface).

In looking only at local pedon descriptions which fall within the taxonomic range of the Norfolk series, one probably could derive a local range of characteristics considerably narrower than the total taxonomic range. However, by looking at other series used in the same survey (and frequently on the same landscape) with profile characteristics delimiting or "bracketing" the taxonomic range of the Norfolk series, a different conclusion is arrived at. Since the soil cover is a continuum, this interseries "bracketing" is good presumptive evidence that if one could observe a large enough sample of pedons in this survey area meeting the taxonomic definition of the Norfolk series, one could view representatives of the taxonomic range—probably again and again. That is, there is good reason to infer that the local range of characteristics approximates the allowable taxonomic range.

Interseries bracketing

Conclusion

In the soil survey, as in any large scale technical program, the activities engaged in must be based upon sound theory and technique. The current practice, deriving local ranges of characteristics for taxonomic units by arraying data from a very small sample arbitrarily restricted to those observations which themselves fall within the defined range of the unit under consideration, is questionable. To derive a local range of characteristics for various classes within a local population, one must array data from the entire population and make comparisons among classes. If this logical approach is taken, a pattern will emerge. It will be found that in many cases the local range of characteristics for soil series will be the same as the allowable taxonomic range.