Trials of the Catena-Drainage Profile Keyform as a Frame of Reference in Pedological Taxonomy[1]

T. M. BUSHNELL, Purdue University

Assuming that "natural classifications" involve (1) recognition, or mental "creation" of units of a discipline and (2) arrangement of those units according to their likenesses and differences, the writer has prepared a "Key" to classifications of Indiana soils by drafting a series of tables and papers (1, 2).

The original "units" were soils already established by soil surveys so the main task was the second step, or the "arrangement" of those units. Even then the operation was chiefly one of crystallizing some common practices of soil surveyors into certain forms.

Reflecting customary thinking of field men, the key assumed the form of a simple tabular arrangement of soil names on lines and in columns with distinguishing descriptive terms at the sides of lines and as headings of columns.

Soils named on the same line were linked by similarities in their descriptions of parent materials, age, vegetation and climate, but differed in features reflecting differences in water regime. Such a grouping was a well recognized class long before the term "catena" was applied to it. Milne had used "catena" (8) somewhat differently, yet approved of this (3) use of his term with the Indiana Key on the basis of his personal acquaintance with Indiana soils and soil survey work.

In the key an attempt was made to array the soils of each catena on their respective lines in such a way that the names of soils with comparable water regime should appear in the same column and conform to the same general description.

In some cases the soils of different catenas, but named in the same vertical columns, are very much alike especially in upper horizons, but, due to the wide range of characteristics found in the complete set of soils, about the only sure generalization is that members of each catena are located on their line according to features reflecting "drainage" and are arranged in gradations with the names of more closely related soils being adjacent and those unlike being farther apart.

However within each column there is a general similarity in essence of the criteria, or the position of each solid relative to other members of its catena.

The general concepts exemplified by the soils listed in each column came to be called "major drainage profiles." The original table had each column headed by a Roman numeral, which, without premeditation

[1] Purdue University, Agricultural Experiment Station, Journal Paper No. 1036.

but by common usage, became the general name of the general concept—such as "I Profile," "II Profile," etc.

The original order of the column headings was based on a diagram (2, 3) illustrating gradations in a "hydrologic sequence" which may comprise a catena. In turn, that diagram probably was influenced by the Illinois Soil Survey which used Nos. 11, 12, 13, 14 and 15 for a set of soils grading from very imperfectly drained flats to well drained slopes, and comprising part of a catena—although that term was not in use.

In nature soils may occur about as illustrated in that original diagram, or in a variety of other patterns. Also in tables or diagrams other arrangements may have advantages in some catenas. However, the Roman numerals, with their respective significance as names established by the first usage, are retained with the same meanings in any diagrams or text, just as the words "dogs and cats," refer to the same animals as "cats and dogs"—regardless of word order.

The catena-drainage profile key form was tied to field legends and evolved with several modifications into a device found by experience to be useful, convenient and reasonably adequate for arranging most of the individual soils which were recognized in the soil surveys of the region.

Naturally the principles found good for classifications in pre-key soil surveys could be assumed to be equally good for new work so the Key became a guide for setting up classifications for each new County Soil Survey. New soil separations thus set up would, of course, fit into appropriate pigeon holes or boxes of the key.

Considering all catenas there were 10 steps in the complete range of hydrologic sequence characteristics, hence 10 columns in the key to provide for 10 different major drainage profiles. However, no catena had recognized soils for all 10 profiles so the table had a number of empty boxes. Such empty boxes naturally raise questions whether unknown soils exist and should be recognized to fill the voids. In some cases the "new" separations so predicted from the Key were actually found and named. The recognition of one new soil in a new catena automatically indicated the theoretical possibility of all other members of that catena. However, many catenas had been mapped for a long time without showing any real need for the full number of catenary steps. Fundamentally the Key is a device to arrange existing units and not something to force separations where the nature of soils make them illogical or impractical.

After this Indiana Key had been time-tested and found useful the principles, consciously or unconsciously followed in its construction, were extracted and generalized in paper on "Some Aspects of the Catena Concept" (3).

Later on a study of the soil literature revealed great confusion and varied views about the catena concept and terminology. This was discussed in a paper called the "Catena Cauldron" (5). It would be impossible to conform to the views of all of the authorities, so the Indiana viewpoint was retained.

In 1944 the writer speculated about the feasibility of using the Catena-Drainage Profile Keyform as a frame of reference (4) in constructing a world soil classification. While this device seemed fairly good for the soil conditions where it was developed, the question was whether, how or where it might fail to be suitable for arrangement of soils recognized by pedologists elsewhere.

It was suggested that, if "local" keys of soil separations were made everywhere by arranging the individual units according to the same basic principles as those followed in the Indiana Key then those local tabular keys could be arranged logically in several ways in reference to each other.

It was recognized that the concept of "local" used in this way is about equivalent to considering different climatic complexes which have different soils characteristic of them in comparable sites, etc. The paper mentioned above considered "different" climates in terms of different combinations of rainfall, temperatures and evaporation. That simple, theoretical diagram illustrating the general idea did not take into account the patterns of wet-dry seasons, and did not make use of studies which have recognized certain climates as significant in pedogenesis. Actually a relatively small number of kinds of "climates" may be needed, but the decision on numbers should not rest on some theory about climatic specifications, but upon actual different soil separations which must use different climatic factors to explain the characteristics which differentiate them.

It seemed logical that this general proposal is feasible because all soils are conceived to be functions of "5 canonical factors" (7) and every soil must reflect every factor. Hence every soil must have characteristics which could define its catena, and also features which specify its water regime and therefore its major drainage profile. If so, they can be arranged in tabular keys in accordance with these functions and characteristics.

Of course, as well known, almost all older soil separations and many newer ones are complexes or "polymorphs" (3). That is, they are broadly defined to cover several boxes in a tabular key. They are not true species, but can be placed relative to each other on the key grid.

Since raising questions about the keyform the writer has had some opportunities to observe soils in all states of the union, in Canada, Mexico, Hawaii, Guam, Japan, Thailand, Burma, India, Egypt, Italy, Germany, Austria and other countries. Everywhere the general principles for recognition of catenas and major drainage profile members of them seemed to be applicable, even though variations and complexities abound.

The soils themselves are more conformable to a natural system than are the soils men of different places, because of the infinite capacity of the human mind to vary. Thus, the writer could "see uniformity in soil characteristics and relationships according to his viewpoints, where the local classifications would not coincide so well. That is, the specific criteria and techniques produce different taxonomic and therefore different cartographic units, but the soils themselves could be defined and arranged uniformly.

For instance, in Bavaria some excellent soil studies are made, partly in connection with land valuation, by following a systematic grid for borings, pits, samples, analyses, etc. Apparently fields, rather than natural soil areas, are a first consideration, although the latter will show up in maps. A field may be characterized by its major components, although allowance is made for minor components. The places examined under the grid system may fall at any point on the natural soil pattern and may represent a transitional condition which the American Soil Survey would try to avoid because borings are made in places away from boundaries, and nearer the centers of areas judged to be "typical" of some type. The American system probably produces fewer and more uniform concepts while the German method seems to produce a wider variety of soils, and a set of separations which would not fit a catena-drainage profile key so well because they were not made by such specific judgments. They probably could be placed in such a table but would fall in intermediate positions, or perhaps have some special features not considered as criteria in setting up a key.

It may be an open question whether a systematic approach will hinder full, accurate and reasonable evalution of nature, or produce a better result. In general, classifications try to have consistent standards and set up codes for uniformity. In pedology there is much opportunity for divergence, and independent studies may give a confusion of tongues like the tower of Babel. There may be more difference between two schools of thought in the same language than between views of people with different languages.

In a Soil Survey of Hokkaido, Japan (1946) the writer used a field legend and made separations in harmony with the Catena Drainage profile viewpoint, as previously described (6).

In Burma the writer undertook a "land classification" of extensive areas by photo interpretation with a group of trainees. Assuming that natural principles are valid everywhere the classification was set up with coded 6-digit symbols which indicated climate, vegetation, catena (from geology-material and age) drainage profile, topography and erosion. In spite of differences in latitude, longitude, climate, geology and agriculture the same sort of symbols and judgment were used successfully in Burma as in Indiana.

Although opportunities for field checks of office interpretations were limited, there were gratifying confirmations in most inspections of the classification.

For example, areas marked 8 (for VII, VIII, and IX profiles) were found to be wet basins with dark, mottled soils. An exception was where both aerial and ground observation showed a wet swale, but the surface soil was reddish for some undetermined reason.

Another example was where pictures showed karst land-forms typical of limestone materials with varied slope classes. As expected, a typical black Rendzina profile occurred on the steeper (D) slopes, while shallower red soil was found on C slopes with deeper red soil on the B slope. Some depressions with high water tables showed the normal water-logged profiles of VIII profiles.

In the important agricultural areas of the Irrawaddy valley some rather sharp distinctions could be drawn from the picture patterns which were confirmed by field checking. There were differences in materials, drainage profiles, degrees of weathering with age, etc. It was even possible to see where brackish tide waters affected the delta lands, in contrast with the older areas leached by heavy rains, or fresh alluvium deposited by fresh waters along the river distributaries.

In the more lateritic regions of Burma the deeply weathered profiles exhibited a variety of high iron layers with somewhat the expected color shifts with drainage, but the porous structure did not allow the degree of imperfect internal drainage which occurs on flats or gentle slopes in Indiana soils.

In Italy, near Rome and in the Po Valley many soils had familiar appearances as would be expected from the site factors, much like in Midwest soils. They should fit in catenas.

In the glaciofluvial and loess lands of the Danube river and its tributaries the soils resemble many corresponding types in Indiana, with some modifications and odd occurrences. For instance on gravel plains near Munich there are some areas (not basins) of muck and/or marl on the surface which are due apparently to rise of ground waters which carry the runoff from the Alps.

Also some soils comparable to the Fox types in Indiana seem to have less advanced horizon development, perhaps due to less age or different materials.

Loess deposits in Austria are extensive and some soils are comparable to those of Indiana but apparently the climatic balance is not favorable to the leaching which produces much soil acidity, or pronounced textural profiles.

All in all, the writer has increased faith that the tabular, Catena-Drainage Profile Key is a device which gives very sound arrangements of soil units in "local" regions, and the soils of all regions, if so keyed locally, can be clearly interrelated by arranging the local keys in logical order.

All of the intricate and significant facts and principles revealed by applied and fundamental researches with physical, chemical and biological tools depend for their importances, upon connecting them with soil taxonomic units, morphological nature and geographic distribution of kinds of soils. Without such tie-in these scientific data are just information about dirt in a sample, on test-plots in a field. A soil key should help use of such data, with or without soil surveys.

Soils are three dimensional bodies whose chief characteristics for recognition, description, interpretation and utilization are in surface features from which unseen profiles are inferred. The important profile features must be connected with surface forms and geography. The whole soil complex needs be located in a three dimensional framework of climate, catenas and drainage, with details of slope and erosion being important local features and present cover or land use being of great practical importance.

These items can be indicated on tabular keys and a consideration of soils can be started from any of various key facets which may be known and proceed from there to other facts which identify soil types and their significance.

Literature Cited

1. BUSHNELL, T. M. 1927. A key to soil profiles in Indiana. Proc. First International Soil Congress. pp. 909-914.

2. ————. 1944. The story of Indiana soils. Purdue Univ. Special Circular 1.

3. ————. 1942. Some aspects of the soil catena concept. SSSA Proc. **7**:466-476.

4. ————. 1944. The catena-drainage profile key-form as a frame of reference in soil classification. SSSA Proc. **9**:219-222.

5. ————. 1945. The catena cauldron. SSSA Proc. **10**:335-340.

6. ————. 1948. Observations on hydrologic sequences in soils of America and Japan. SSSA Proc. **13**:481-483.

7. JENNY, HANS. 1946. Arrangement of soil series and types according to functions of soil forming factors. Soil Science **61**:375-392.

8. MILNE, G. 1936. A provisional soil map of East Africa. Amani Memoirs, East Africa Agricultural Experiment Station.