Teaching soil morphology to introductory soil science students

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ABSTRACT

Introductory soil science students should receive practical instruction in soil morphology because it can be a tool to assess soil limitations for various land uses. "Real soils" should be examined whenever possible. Soil cores collected from a toposequence are well-suited for classroom instruction because the soils frequently exhibit a wide range of morphological features associated with differences in drainage. Cores of soil 1.0 m long can be collected quickly using a hydraulic coring machine and can be stacked and stored conveniently on special trays. In the laboratory, soil profile descriptions are completed as would be done in the field by describing horizon type, thickness, color, texture, structure, etc. Toposequence cross-sections can be prepared from profile descriptions to show variations in horizon properties down the hillslope. Soil series and soil boundaries can be readily seen in the cross-sections. Surveys of students in introductory soil science courses indicated that these exercises using soil cores were an enjoyable and meaningful way to study soil morphology.

SOIL MORPHOLOGY is the branch of soil science that deals with the identification and description of soil horizons. Many land management decisions for both nonagricultural and agricultural uses are based on soil conditions that can be determined by examining soil morphology. For example, gray soil colors usually indicate the soil is seasonally waterlogged, and this condition can cause septic systems to malfunction, kill plants, produce wetness problems for basements, and indicate the soil is susceptible to flooding (Buol et al., 1980). By learning to recognize gray soil colors, a soils student may be alerted to these potential problems on land he or she is considering buying or is trying to manage. Soil morphology can also be used to help make tillage decisions. In some coarse-textured soils where the E horizons are compact and form a tillage pan, the root system is restricted and yields may be low during dry years due to plant moisture stress (Vepraskas et al., 1987). Crop yields can be increased in these soils by subsoiling to rip or fracture the pan, but such tillage should only extend to the top of the B horizon to avoid eventually deepening the compacted layer (Trouse, 1983). These two examples illustrate that soil morphology should be of practical interest to beginning soil science students.

We believe that soil morphology should be taught to introductory soil science students. To do this effectively, students must be given an opportunity to gain "hands-on" experience in describing soil morphological characteristics. Students need to practice identifying and describing horizons on "real soils" where they can use soil characteristics such as color and texture (by feel) to delineate horizons. Monoliths consisting of soil profiles permanently glued to boards or trays (Malo and Nielsen, 1985) are not well-suited for this purpose because only certain visual properties (e.g., color, structure) can be assessed. Other important morphological properties such as texture and consistence cannot be evaluated in monoliths. Use of soil pits for soil morphology instruction is ideal but can impose logistical problems in transporting students to the site, providing adequate space for students to work in the pit, and waiting for reasonable weather to work outdoors. Such constraints often make the use of soil pits impractical for 2-h laboratory sessions.

An alternative to soil pits for teaching morphology is to bring undisturbed soil cores into the laboratory where they can be evaluated and described by students (Lemme, 1983). If enough cores are taken, students can work individually or in small groups to complete exercises. While it is not feasible to let students work intensively on a large number of different soils, cores can be collected from soils that possess important characteristics common to many soils. Such characteristics include having the major soil horizons (Ap, E, and B) present, as well as having textures common to the area. Another important characteristic that should be apparent among cores is the change in soil color caused by seasonal waterlogging. Well and poorly drained soils (soils with udic and aquic moisture regimes, respectively) must be managed differently for various agricultural and nonagricultural uses, and it is important that students be able to see the fundamental morphological differences between these soils.

All the above soil characteristics can be found in soils along a toposequence. A *toposequence* is a group of related soils that differ from each other primarily because of topography as a soil-forming factor (SSSA, 1975). Soils along a hillslope comprise a toposequence, and often differ from one another in drainage class (Fig. 1). We believe that soil cores collected along a toposequence pro-

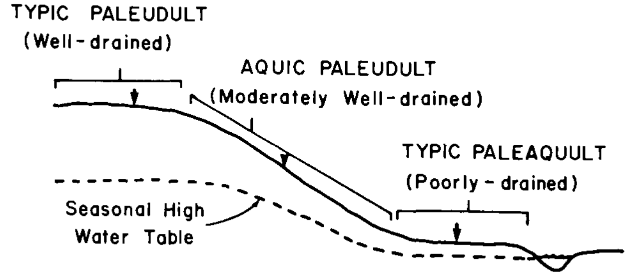

Fig. 1. Representative toposequence consisting of three soils with different soil moisture regimes and drainage classes.

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vide the best examples for beginning students to use to study soil morphology. In addition, the use of toposequence soils allows some of the concepts of soil formation to be integrated into a laboratory exercise.

This paper presents how basic soil morphological concepts can be taught to introductory soil science students using soil cores collected along a toposequence. The procedures discussed have been used successfully for more than 7 yr.

MATERIALS AND METHODS

Soil cores were collected along a toposequence consisting of three soils as shown in Fig. 1. Cores were collected from the three hillslope positions indicated by arrows. At each of the three hillslope positions, cylindrical soil cores approximately 1.0 m long and 0.08 m in diam. were collected using a hydraulic coring machine (Giddings Machine Co., Fort Collins, CO).[1] Extracted cores were stored in special trays (Fig. 2), which were lined with aluminum foil. Each intact core was placed over the foil in a tray, and the foil was then tightly wrapped around the core. The foil served as a moisture barrier and kept the soil moist for several weeks. Without the foil, the cores would quickly dry out and become hard, making them too difficult to pick apart. The trays were designed so that they could be stacked when filled with a core (Fig. 3). This facilitated both transport from the field as well as laboratory storage. In the laboratory, the trays can be stacked 10 high until needed.

Ten soil cores were normally collected from each of the three soils over a 4-h period by three people. This number of cores was required for a class of approximately 100 students containing seven laboratory sections of approximately 15 students each. Each laboratory section was provided with one set of three cores. Three extra sets of cores were collected for a variety of purposes including display, replacement of damaged cores, and sharing with other courses.

LABORATORY USE OF CORES

Each student was expected to prepare profile descriptions of the three soils of the toposequence. Definitions of soil profile and major horizons were provided prior to the laboratory. Criteria used to describe a soil core are shown in Table 1. Students usually worked in groups of five or less in completing descriptions.

Students were instructed to begin profile descriptions by dividing each core into horizons. This was done largely on the basis of color and texture. The Ap horizons were easily identified on the basis of color, and the upper boundary of the B horizon was determined on the basis of texture by feeling for the depth at which the clay content increased. The E horizons normally were present in the soils examined and were determined last. Transitional zones between horizons could be difficult to describe, because students had to decide whether these were separate horizons (e.g., EB) or were simply gradual or diffuse boundaries between the major horizons. Horizon boundary topography (e.g., smooth, wavy) cannot be realistically described from a core. Low chroma (i.e., gray) drainage mottles were given special attention because of the obvious changes down the hillslope. Soil structure was usually weakly developed in the soils of the toposequence used, but an estimate of the type of structure visible was made by the students.

Students used the profile descriptions of each core to plot a cross-section of the toposequence. The profile descriptions were first diagrammed on a sketch of the hillslope (Fig. 4A), and then the horizons were connected

[1] The use of trade names in this publication does not imply endorsement by the North Carolina Agricultural Research Service of the products named, nor criticism of similar ones not mentioned.

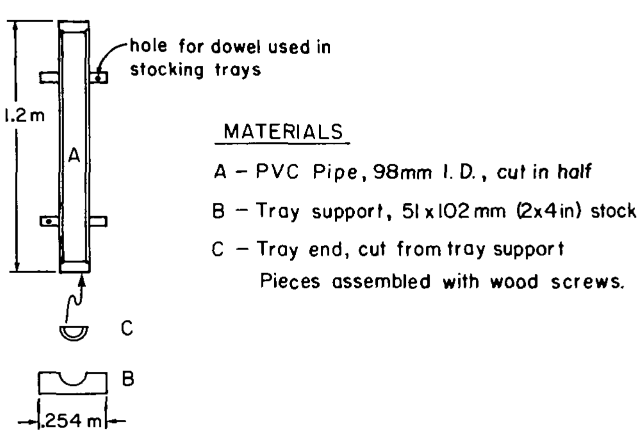

Fig. 2. Materials and dimensions of trays used to store soil cores.

Fig. 3. A stack of soil trays stabilized by wooden dowels. Trays filled with soil cores can be stacked at least 10 high using dowels.

among soils. The horizons and special features (e.g., mottles) were colored appropriately to show how soil properties changed across the toposequence (Fig. 4B). An estimate of the seasonal high water table was made by drawing a line across the upper zone of gray mottles or horizons of gray color. Soil series could be readily seen and identified on the cross-section. In addition, the gradual changes of one soil into another were readily apparent.

The value of having students plot a toposequence cross-section (as in Fig. 4B) is that such diagrams show them how soil properties systematically change along a hillsope. Ideally, students notice that morphological changes such as soil color are predictable across a landscape. Some students have even examined soils across hillslopes outside of class to see whether the expected changes actually occurred.

STUDENT EVALUATIONS

During the spring semester of 1985, 74 students enrolled in the introductory soil science course were asked to evaluate the laboratory exercise that used soil cores to teach soil morphology. During the spring semester of 1986, 76 students evaluated the same exercise. The results of the student surveys were similar both semesters.

The exercise followed a similar exercise where students reviewed soil horizon definitions and tried to apply them to soil monoliths. Students were polled after the monolith and core exercises were completed.

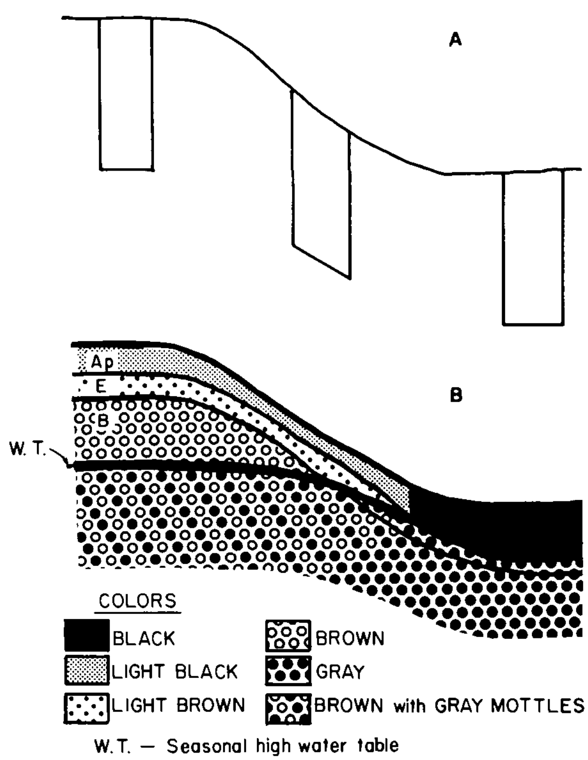

Fig. 4. Toposequence cross-section. (*A*) sketch of toposequence supplied to students; (*B*) completed diagram after profile description data were plotted and horizon variations diagrammed across hillslope.

Approximately 61% of the students (both semesters combined) felt that use of soil cores for teaching soil morphology was more instructive than use of soil monoliths. Sixty-seven percent of the students felt they could identify Ap, E, and B horizons in the field after having completed the laboratory exercise. Seventy-six percent of the students enjoyed working with soil cores, although some parts of the exercise were frustrating. Approximately 20% of the students complained that some soil horizons (primarily transitional horizons) did not clearly conform to any horizon definition, and they disliked having to decide which definition applied best. Although making such decisions can be frustrating, it has to be done frequently when describing soils in the field. It is beneficial that students realize early in their career that such decisions must be made when describing soils.

CONCLUSION

We have found use of soil cores from a toposequence to be a relatively simple and highly effective way to teach soil morphology to introductory soil science students. The approach described could also be easily modified for use by advanced students in upper-level courses. The soil cores have an advantage in that they can be used in a laboratory setting while allowing students to develop the descriptive skills that are used in a field situation.

ACKNOWLEDGMENT

The soil trays were made by Fred Averette, who was also responsible for key design modifications, which made the trays rugged and easy to use. Fred's help is gratefully acknowledged.

Table 1. Criteria used to describe soils for profile descriptions.

1. Horizon type—A, Ap, E, B, C
2. Horizon depths
3. Horizon boundary—The thickness of the zone between two horizons

Abrupt:	<25 mm
Clear:	25-64 mm
Gradual:	63-125 mm
Diffuse:	>125 mm

4. Horizon color—Dominant color of horizon
5. Presence of gray mottles (spots of gray color). Estimate amount of gray mottles

Few:	<2% of horizon
Common:	2-20%
Many:	>20%

6. Textural class—Estimate of amount of sand and clay. Use one of the terms shown below†

	High sand	Low sand
Low clay	Sand	
	Loamy sand	
	Sandy loam	Loam
	Sandy clay loam	Clay loam
High clay	Sandy clay	Clay

7. Soil structure—Type and strength of aggregates

Type	Strength
Single grain	
Massive	Weak
Granular	Moderate
Platey	Strong
Blocky	

† Silty textures are not found in the soils considered and were not considered in the exercise.

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