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Editor's Note

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Thoughts on Soil Classification

By Robert J. Ahrens, Director, National Soil Survey Center, USDA, Natural Resources Conservation Service, Lincoln, Nebraska.

Having worked on Soil Taxonomy for over 10 years and then away from the day-to-day activities of soil classification for the past 7 plus years, I have developed a certain bias that I am willing to share with you.

Most pedologists recognize that soils by their nature are difficult to classify. Unlike plants and animals, soils do not occur in discreet bodies but form a continuum with some obvious abrupt interruptions over the earth's surface. Soil classifications are not truths that can be discovered, but rather methods of organizing information in ways that seem logical and useful. The best ways of organizing information about soils can elicit heated debate without a clear resolution.

Presently, two soil classification systems dominate the world, Soil Taxonomy and the World Reference Base (WRB). I do not know the number of countries using each system. WRB is more prevalent in Europe and Africa, whereas Soil Taxonomy is more commonly used in Asia and South America.

WRB began as an attempt to provide a national legend for world soil maps. It has evolved into a soil classification system that has gained acceptance by the International Union of Soil Science (IUSS) and is adopted by several countries as the national soil classification system. WRB was never meant to replace any country's national system. Soil Taxonomy, on the other hand, was developed as a universal soil classification system that would encompass all the known soils on earth. We have spent a considerable amount of time and effort on accommodating and addressing the soil classification needs of the international community. After Guy Smith's death, much of the credit for making Soil Taxonomy an international system goes to Hari Eswaran, who headed the Soil Management Support Services (SMSS). The SMSS supported the use of Soil Taxonomy worldwide through conferences, workshops, and tours.

Why was Soil Taxonomy not promoted by the IUSS and used by all countries? Some pedologists, mostly in Europe, do not believe that soil temperature and soil moisture regimes are soil properties and thus do not think that these regimes should be included in a soil classification system. Guy Smith debated the merits of soil moisture and soil temperature and demonstrated that both are properties of the soil that can be measured much like other important properties. Soil temperature and especially soil moisture provide challenges to scientists writing operational definitions that can be easily applied in the field. In some areas of the United States, we find it difficult to apply soil temperature and moisture regimes consistently. However, the temperature of a soil and the time when it is moist and dry are extremely important characteristics of the soils. I would hope that most pedologists would recognize the importance of being able to separate a Vertisol in Texas from a

Vertisol in Canada with very similar genesis and morphology, but very different climates.

Some pedologists do not agree with the hierarchy of Soil Taxonomy. For example, soils that we consider to have aquic soil moisture regimes merit their own order in several national soil classification systems. Soil Taxonomy recognizes aquic soil conditions close to the surface at the suborder level. The hierarchy of a soil classification system can be easily debated, and there really is no correct or incorrect way to build the system.

There are likely other reasons for the reluctance of European soil scientists to embrace Soil Taxonomy, Some of these reasons are likely to be political, and some perhaps are personal. One common criticism is that Soil Taxonomy is too difficult and cumbersome.

Philosophically, we in the soil science community understand the advantages of having a common, universal classification system. The plant and animal scientists have common classification systems that allow the scientists to communicate with each other. The reality is that a common soil classification system will be very difficult to achieve. Most countries have favorite or special soils that they want recognized at a high level in the classification schema. WRB tried to appease pedologists from many countries and uses a combination of names for the reference soil groups or soil orders. Some of the soil orders have names that are the same as or similar to the names in Soil Taxonomy. Examples are Andosols and Histosols. Other soil names represent classical soils, such as Chernozems and Podzols. The problem with some of the classical names is that, although the soil characteristics were somewhat defined when the soils were first recognized, there are no operational definitions that clearly separate the soils from other soil orders and with time the original concepts became fuzzy. Podzols, for example, were originally defined in terms of an E horizon that could be above an argillic horizon or a spodic horizon. With time, many pedologists considered the Podzols to be similar to Spodosols.

WRB is a two tiered-system. The reference soil group or soil order represents the broadest level of WRB. Rather than 12 soil orders, as in Soil Taxonomy, the WRB has 30 reference soil groups. The second level of WRB is the formative elements that include diagnostic horizons and properties and attributes, such as color, chemical conditions, and texture. The formative elements are prefix qualifiers and suffix qualifiers. Examples include Vertic Cambisols, sodic; Petric Gypsisols, skeletic; and Calcic Chernozems, siltic. Because of its simplicity, WRB appeals to some pedologists. It is not practical for use in detailed mapping, however, because it does not have enough levels to recognize and distinguish the important soils. Pedologists mapping in Italy and using WRB are concerned because many of their soils fall in the same taxa. WRB errors on the side of simplicity and requires the mappers to carry too much information at the series level in order to make meaningful soil separations. In the United States, our early attempts at soil classification had similar severe limitations. Currently, Soil Taxonomy is the only soil classification system that has been successfully used to map a diverse area the size of the United States at a detailed scale.

Unfortunately, the world of pedology is not able to accept one universal soil classification system at this time. A few pedologists are attempting to do deal with this problem, and their efforts are gathering the momentum for building a universal system. The best we probably can achieve is a common set of diagnostic horizons and features with common definitions. Before his retirement, Bob Engel worked closely with the WRB Working Group to harmonize the definitions of the diagnostic horizons and features between WRB and Soil Taxonomy. This has been a first step and a fruitful endeavor. Many of the definitions are now the same or very similar in the two systems. Common diagnostic horizons and features promote a common language among pedologists, even though the pedologists do not agree on the priorities or on how these building blocks are assembled into a soil classification system.

The diagnostic horizons and features are the greatest major breakthrough in soil classification in the last 70 or more years. Unless another major advancement in soil classification is on the horizon, we will continue our efforts to maintain and enhance Soil Taxonomy. Although far from perfect, Soil Taxonomy is a powerful tool for communication and correlation. We simply do not have the resources to develop a new soil classification system.

The future soil survey program must strive for more balance. We need to increase the resources that we devote to technical soil services and at the same time enhance existing interpretations or develop new ones and develop geographical ways of displaying the interpretations. We also need to be cognizant of our data needs, the quality of our data, and ways to communicate information about data issues and gaps to our users. ■

Enabling the Desert Project

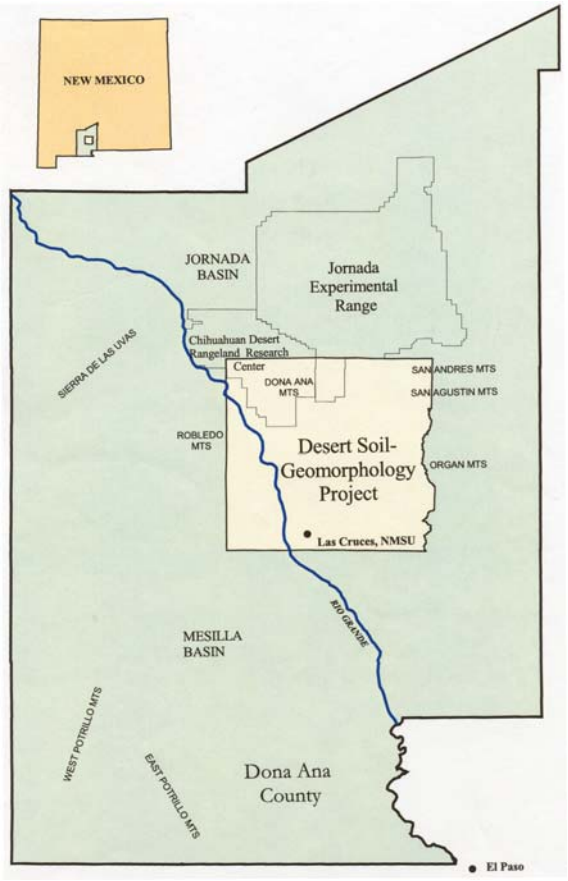
By Bob Grossman, Research Soil Scientist (retired), Soil Survey Center, USDA, Natural Resources Conservation Service, Lincoln, Nebraska ; prepared for the 50th Anniversary Desert Soil-Geomorphology Project tour, May 21-25, 2007, New Mexico State University, Las Cruces.

Introduction

This year marks 50 years since initiation of the Desert Project. The purpose of this essay is to discuss the visionary for the project, the patron, and the sponsoring organization. The visionary is Guy D. Smith, the patron is Charles E. Kellogg, and the initial primary sponsor is the Soil Conservation Service (SCS), now the Natural Resources Conservation Service. SCS was (and NRCS is still) an agency largely devoted to application of proven technology to agricultural land utilization, not to the science displayed by the Desert Project. How then was SCS a sponsor?

I worked for Guy Smith directly, had contact with Dr. Kellogg, and was a long-term employee in SCS and NRCS. Much of the information in this essay comes from David Gardner's excellent Ph.D. thesis (Gardner, 1998), from the fine discussion of Dr. Kellogg in a history of Soil Survey (Helms, 2002), and from my paper on G.D. Smith (Grossman, 2004).

Bob Grossman, at left, and Lee Gile sampling a pedon in a mine pit near Organ.



Location of the Desert Project in Dona Ana County, southern New Mexico.

Guy D. Smith

My first selection from Smith's writings is, in a sense, a conclusion. It is from the Foreword to the publication of the Southwest Iowa Soil-Geomorphic Project begun in 1953 (Ruhe, et al., 1967):

> In soil mapping the scientist looks for changes in the soil wherever there is a change in one of the soil-forming factors. The extent to which he can identify and interpret correctly changes in the age of the land surface influences the efficiency of his work and the accuracy of his maps.

The practically evident in this quotation is a thread that runs throughout Guy Smith's career.

Guy Smith was born on June 20, 1907, in Atlantic, Iowa, nearly 100 years ago. He died on August 22, 1981. He graduated from the University of Illinois in 1930, worked in the Illinois state soil survey from 1930 to 1933, completed an M.S. degree at the University of Missouri in Soils in 1934,

worked on land acquisition for the Federal Resettlement Administration from 1934 to 1936, returned to the Illinois soil survey, and while there completed a Ph.D. in Soils in 1940. He served in the U.S. Army Air Force from 1942 to 1946. In 1946, he joined the Federal soil survey, where he remained until his retirement.

Guy Smith completed his M.S. thesis (Smith, 1934) under Hans Jenny. It was a laboratory experiment on claypan formation. The following is from near the end of the thesis, effectively a summary statement:

> Correlated field and laboratory studies are needed before the relative importance of the various factors in pan formation can be determined for any of the natural clay pans.

The statement almost seems to negatively assess his laboratory studies in favor of field studies.

Later, Smith elaborates on the importance of field work (Smith, 1941):

> Field workers, principally soil surveyors, have a practical interest in studies relating to soil development which is shared by no other group. The soil surveyor in his mapping work, if he follows an intelligent mapping technique, is constantly faced with the necessity of predicting soil occurrence…. Obviously, the correctness and, therefore, the usefulness of the map which he is making will depend not only on his skill in recognizing a given combination of soil features but also on his ability to predict correctly where this combination may occur.

As was the practice, oral discussions occurred after papers were published. Here is an exchange (Smith, 1941):

> Jenny: Would you explain why you assume that erosion is an independent soil-forming factor?
>
> Smith: I consider erosion to be an independent soil-forming factor because on similar slopes with similar parent material it may or may not have occurred. Within limits, geologic erosion seems to have a random relation to slope.

Jenny's book *Factors of Soil Formation* (Jenny, 1941) was published in the same year as the exchange with Guy Smith. The book was widely used in teaching. Jenny did not discuss geological erosion. Perhaps the key to why not is the statement to the effect that the book is "about soil formation, not destruction" (p. 89). Where geological and pedological processes are distinguished (p. 55), the examples of geological processes are of aggradation of parent material (e.g., loess deposition), not removal.

Following is a quotation from Smith's Ph.D. thesis on loess thickness and soil development. It illustrates the analytical mind he brought to field investigation (Smith, 1942):

> The soil developed in very thick loess will have weathered from the loess laid down toward the close of the period of loess deposition and essentially will have been weathering only since loess deposition ceased. On the other hand…the soil development in thin loess…has had an equal number of years to develop but has developed from material which has been greatly altered by weathering during the long period of loess deposition.

This quotation is consistent with Jenny's thinking.

After service in WW II, Smith joined the Federal soil survey, stationed at Iowa State University as a correlator. The correlation staff members were direct field representatives of Dr. Kellogg. Landscape-soil relationships were under active investigation at Iowa State. For example, there is the remarkable paper by Aandahl (Aandahl, 1948) that explores improvement of corn yield predictions by introducing field-scale landscape position.

On p. 251, the 1951 *Soil Survey Manual* (USDA, SCS, 1951), states:

> Natural geological erosion in the natural landscape may be either a gradual process…or a catastrophic one. Once started in a new cycle of erosion – initiated by uplift, changes in climate…or other causes – a large part of the solum…may be removed rapidly. Reconstruction and the formation of a new soil then follows the stabilization of the landscape again.

This quotation comes close to perhaps the most important tenet of the Desert Project. It may have been written largely by Smith. Smith's response to Jenny in 1941 was not the viewpoint of one of the two Federal soil surveys. Why there were two will be discussed later.

In 1953, only 4 years prior to the establishment of the Desert Project, Smith went to Washington, D.C., as Dr. Kellogg's Director of Soil Survey Investigations. He soon hired Dr. Bob Ruhe. After completion of his work in

southeast Iowa, Bob Ruhe moved to Las Cruces to begin the Desert Project.

Guy Smith said that the two requirements for location of the project were noncarbonate parent materials and a university library. The noncarbonate parent materials were required to study the large amounts of seeming authigenic carbonate. The university library requirement shows the importance of New Mexico State University, even before initiation of the Desert Project.

Development of the system described in *Soil Taxonomy* (USDA, SCS, 1975) is considered Smith's crowning achievement. The active development of the taxonomy system early in the history of the Desert Project was a shield against detractors. Soil survey people generally agreed on the need for a new classification system. They were tolerant of the diversion of resources to the soil-geomorphic projects. Guy Smith stated that it was a close decision whether to adopt the new system. Would the Desert Project have survived in the early years without the prestige resulting from Guy Smith's development of soil taxonomy?

The so-called "airport trenches" in the upper La Mesa. Bob Ruhe stands at the junction of the trenches. Photographed in August 1959.

Charles E. Kellogg

Dr. Kellogg was a professor in his early thirties at what is now North Dakota State University when he was picked in 1934 to be Assistant Chief, Bureau of Soils and Chemistry. In 1935, he became Chief after Curtis Marbut relinquished the position.

Marbut had stressed soil genesis. The soil survey was small and devoted largely to identification of soils genetically. Because of his previous experience, Kellogg initiated a much greater emphasis on soil behavior.

Dr. Kellogg obtained his degrees at Michigan State University. His major professor worked on land classification. Kellogg had a fellowship to apply the soil survey to location of highways and thus reduce the need for highway repair. As a professor at North Dakota State, he initiated a soil survey for use in part to obtain equitable taxation in rural areas. In Washington, he continued work on what was (and is) called "interpretations." He largely wrote the 1937 *Soil Survey Manual* (Kellogg, 1937) and was instrumental in development of the 1951 manual (USDA, SCS, 1951). The manuals are handbooks on doing a soil survey; soil genesis is not discussed. I attended several work-planning sessions that Dr. Kellogg chaired. Interpretations predominated.

The practicality of his soil survey program may lead one to think of him only as a successful manager. There was a lot more to him. Dr. Kellogg was a person of action and letters, a Theodore Roosevelt type. In the 1937 *Soil Survey Manual,* he included a bibliography (not a reference list) of scientific publications. He subsequently assembled an extensive reading list for soil scientists that included literature as well as technical publications. He was a recognized authority on James Joyce. Perhaps it is not a coincidence that his son became an English professor specializing in the Icelandic sagas.

The Soil Conservation Service (SCS)

The SCS has roots in the Depression of the 1930s. It was established in 1935 as an instrument to provide funds from the National Recovery Administration directly to farmers. The National Erosion Service, in the Department of

the Interior, was transferred to SCS, including its soil survey program. There were then two soil survey programs in USDA—that in the Bureau of Soils with ties to Marbut and before, headed by Dr. Kellogg, and the SCS soil survey program that originated from the National Erosion Service, with a more "utilitarian" mission. The soil survey in the Bureau of Soils and Chemistry (and after 1938, the Bureau of Plant Industry) was to supply the soil classification and technical guidelines to make the SCS soil surveys. Slowly, the connection between the two survey programs decreased. The SCS soil survey prospered because it addressed directly the mission of the SCS of direct help to farmers. By the end of WW II, the SCS had established a comprehensive program to map individual farms. Following is a description of the mapping practice and criteria (USDA, SCS, 1954):

> …soil scientists…walk over the ground, bore or dig holes in the soil, and determine its depth, texture, permeability, available moisture capacity, inherent fertility, organic-matter content, and other characteristics that affect the use, management and treatment of the land… They measure the slope, determine the degree of soil loss by erosion, the overflow hazards, the wetness of the land, and other significant characteristics. They note also the present use of the land. These facts are recorded on aerial photographs for later use by farmers and others.

After much travail, Secretary of Agriculture Charles Branman in October 1952 combined the soil surveys of the Bureau of Plant Industry and the SCS, placing both in SCS and Dr. Kellogg in charge. The decision was not to be implemented until after the election in November 1952. Ezra Taft Benson, the new Secretary of Agriculture, in November 1952, released the plan for soil survey consolidation. The plan established the Agricultural Research Service (ARS). All research projects in SCS were transferred to ARS with the exception of "investigations required for the national soil survey of the Soil Conservation Service." The phrase is the legal basis for the Desert Project that began 4 years later. It may be observed that SCS had an excellent hydrology program, which was transferred to ARS. SCS developed the Curve Number hydrology model, in use today. Hydropedology might be further advanced if the SCS hydrology program had not been transferred to ARS.

Guy Smith said that his first proposal to Dr. Kellogg was the direct measurement of erosion. This was refused. The next was the soil-geomorphology projects. Refusal of the first proposal and acceptance of the second may give insight into the difference between research and investigation in Dr. Kellogg's mind.

The merger gave Dr. Kellogg a much larger budget. At the time of the merger, the budget of the SCS soil survey was four times larger than that of the survey of the Bureau of Plant Industry. These new monies were no doubt instrumental in the start of the Desert Project.

Ironically, assumption of leadership by the soil survey in the Bureau of Plant Industry and, in particular, Dr. Kellogg may have been *because* of the success of the SCS program that provided assistance to individual farmers. Some senior people in the state-controlled programs, in particular the Agricultural Experiment Stations, and in the Extension Service felt that the SCS direct assistance program was a threat—an example of "big government." The program in the Bureau of Chemistry and Soils (later Bureau of Plant Industry) kept to technical aspects of soil survey and was much smaller and, therefore, less intrusive. Further, Dr. Kellogg had been an academic and was known as a scientist. A number of times in my presence, Dr. Kellogg said that the Agricultural Experiment Stations were critical to the decision to combine the two SCS soil surveys and by inference place him in charge. New Mexico State University of the 1950s may have been indirectly a cause of the Desert Project as well as a subsequent major contributor to its success.

Remarks

In the title of this essay, the word "enabling" is used in the dictionary sense "to make possible." Execution of the project is quite another matter. The executors are not discussed. The intent here is the setting for initiation.

Guy Smith simultaneously initiated the soil-geomorphic projects and laid the foundation for the current soil taxonomy system. They are quire different enterprises. Development of a taxonomy system is a sorting process; the soil geomorphology projects involves gathering. The former must be orderly and reductionist; the latter is messy, and its progress may be accidental, not planned. Guy Smith managed the two disparate activities successfully.

Early in his career, Guy Smith experienced the Depression of the 1930s. Perhaps the Depression was formative in the concreteness, simplicity, and practicality of his writing.

The description of the mapping procedure in SCS may explain the

current choice of the word "interpretations" for predictions of soil behavior. In the SCS soil survey prior to the early 1950s, these predictions were criteria for mapping. In the Bureau of Soils and Chemistry, and later in the Bureau of Plant Industry, the soil as a natural body and soil behavior was predicted for the mapped soils.

Chance was important in the enabling of the Desert Project. The soil survey program had two exceptional leaders in Guy Smith and Charles Kellogg, but it was through the chance occurrence of certain bureaucratic changes in the Department of Agriculture that money became available for them to initiate what is here celebrated.

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Florida State Soil Scientist Selected

Following is a message that Joseph McCloskey, State Soil Scientist/MO Leader, St. Paul, Minnesota, sent to Micheal Golden and others in the Soil Survey Division, Washington, DC:

Deanna Anderson

I had the pleasure of offering Deanna Anderson (MLRA Coordinator, Rochester, MN) the Florida State Soil Scientist position by presenting her with a "gator." Here she is accepting the position and gator. ■

On the Road at the American Planning Association

In an effort to spread the word about the importance of soils and the impact they have on daily decisions, the National Soil Survey Center became an important participant in the annual meeting of the American Planning Association (APA) in Philadelphia, on April 13-17, 2007. Over 6,100 planners and GIS specialists attended the meeting, including 1,300 students. More than a third of those people stopped at the NRCS exhibit, which showcased two large computer screens with

Terry Aho demonstratingWeb Soil Survey at the APA conference.

demonstrations of Web Soil Survey, Soil Data Viewer, Soil Data Mart, resources for Farmland Protection, and the USDA PLANTS database.

For the first time, NRCS was invited to be part of the APA agenda by giving a workshop on the importance of soils and the various free online applications available through our Web site. The workshop was part of the National Soil Survey Center's ongoing mission to generate awareness of soils and to encourage people to contact NRCS first when they need information about soils.

More than 2,000 individuals visited the NRCS exhibit. About 500 of these people visited computer stations, where they participated in hands-on demonstrations of the Web Soil Survey, Soil Data Viewer, Soil Data Mart, and other Web sites. At times many people clustered around the computer screens, learning how to access and use NRCS'online soils tools. Many people stayed longer than 30 minutes, exploring, learning, and gathering information that was relevant to their personal projects.

NRCS conducted a workshop as part of the conference's Technology Showcase. Terry Aho, Soil Scientist from the West National Technology Support Center in Portland, gave a 90-minute session on the various online soil applications and their capabilities.

The National Soil Survey Center is planning to participate at the same level in the national conferences of the American Society of Landscape Architects and the National Association of Realtors.

NRCS is already on the list of invited exhibitors for the next American Planning Association annual meeting, in Las Vegas from April 27 to May 1, 2008. NRCS may have the opportunity to present posters and case studies in symposia sponsored by the Environment, Natural Resources, and Energy Division of APA. A major focus for posters and presentations in 2008 is sustainable sites. ■

Wade Hurt Retires

G. Wade Hurt, soil scientist on the Soil Survey Standards Staff at the National Soil Survey Center, has announced his retirement effective May 26, 2007, after more than 37 years of government service.

Wade received his B.S. degree from Mississippi State University in 1968. After a couple years of military service, he began his career as a soil scientist with SCS in 1971 in South Carolina. Duty stations there included Moncks Corner, Columbia, and Orangeburg. In 1978, he moved to Auburn, Alabama, where he assumed the duties of Assistant State Soil Scientist. In 1984, he was selected as State Soil Scientist in Florida and moved to Gainesville. Wade became liaison to the U.S. Fish and Wildlife Service in 1994 and extended his work on Florida hydric soil indicators nationwide.

In 1996, Wade joined the National Soil Survey Center with his major duty being maintenance and education of hydric soil indicators and terminology. In 2006, he received the Soil Science Professional Service Award from the Soil Science Society of America.

After retiring, Wade and his wife, Yukie, will continue to reside in Gainesville, and Wade will begin working as a soil scientist with the Soil and Water Science Department at the University of Florida. ■